Year-End Rush and Career Tournament: Theory and Evidence from Chinese Patent Applications

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Academia Sinica

30 May 2025

Year-End Rush and Career Tournament: Theory and Evidence from Patent Applications in China*

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Abstract

This paper proposes a tournament theory to explain the year-end rush phenomenon—the pervasive surge in organizational activities or investments at period-ends. In a multi-period tournament with observable interim performance, lagging contestants exert disproportionately high effort in later periods to catch up. Because the final period is not subject to future catching-up, the marginal return to effort peaks at the end, generating an effort surge. The model predicts a monotonically increasing relationship between a contestant's interim performance rank and the extent of his year-end rush. We test these predictions using data on patent applications across Chinese cities, where official promotion is well-known to follow tournament-style competition. Our results show: (i) a robust year-end patent application surge, and (ii) a monotonic relationship between a city's rush intensity and its interim performance rank within its province. While China's patent growth target policy has been criticized for exacerbating year-end rushes and reducing patent quality, we demonstrate that the underlying driver is the bureaucratic tournament; growth targets merely exacerbate it. Additional evidence highlights the role of patent agencies in facilitating patent rush.

Keywords: year-end rush, fourth-quarter effect, multi-stage tournament, interim relative performance, career concern, catching-up effect, Chinese patent policy, Chinese bureaucracy

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* The authors would like to express their thanks to Yongmiao Hong for providing an opportunity for our collaboration that has made this paper possible, as well as to Jimmy Chan, Kim Sau Chung, Yosuke Yasuda, Tzu-Ting Yang and Yating Chuang for their comments. The first author is grateful to Chang-Tai Hsieh and Shang-Jin Wei, whose talks at Academia Sinica inspired this paper. We acknowledge Boyang Xu for providing excellent research assistance.

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1. Introduction

The year-end rush (or more broadly termed the "fourth-quarter effect") — characterized by a surge in organizational activities or investment near fiscal year-ends or deadlines--is well-documented across both public and private sectors. For example, in the public sector, Liebman and Mahoney (2017) demonstrate that the U.S. Federal government usually experiences a surge in procurement at the year-end (see also Eichenauer (2020) for public spending surges in OECD countries). Similarly, Kinney and Trezevant (1993), Callen et al. (1996) and Shin and Kim (2002) document a year-end surge in private sector capital investments. Sun et al. (2021) identify a clear rush of Chinese patent applications in November/December, a pattern Park and Shin (2023) also observed in South Korea. Cohen et al. (2021) find that drug approvals surge in December, at month-ends, and before major holidays across a variety of countries. The accounting literature also records a prevalence of disproportional fourth-quarter earnings increases among public companies (e.g., Das et al., 2009). Critically, these surges are often associated with inefficiencies.

The reasons behind the year-end rush vary. Liebman and Mahoney (2017) attribute it to fiscal rules whereby unspent budgets expire at year-end, adversely creating incentives for the U.S. Federal government to accelerate spending. Similarly, Callen, et al. (1996) find evidence that a firm's disproportionately large capital investment in the fourth quarter is consistent with "use it or lose it" consideration. Shin and Kim (2002) show that, although firms have higher fourth-quarter capital investment in general, such investment is less sensitive to investment opportunities; moreover, the surge is more pronounced among larger firms or those with ample cash reserves, suggesting agency problems. Sun et al. (2021) attribute China's year-end patent application rush to the central government's growth target policy, which pressures local governments to rush low-quality innovations when falling behind the target. Cohen et al. (2021) trace the surge in drug approvals to regulators' efforts to meet internal benchmarks tied to calendar deadlines. Das et al. (2009) provide evidence that public firms inflate fourth-quarter revenues to meet investor expectations.[1]

The existing literature has predominantly attributed the year-end rush to institutional rules—namely, "use-it-or-lose-it" budgeting or "meeting-the-target" incentives. Yet the phenomenon's pervasiveness suggests an alternative explanation may exist, one not tied to specific organizational rules. Consider an analogy to long-

[1] In popular culture, the year-end rush for workers in firms is also attributed to the need to meet targets, complete projects, or finalize budgets, etc. See, for example, Michelle Gibbons "Is the End of Year Rush Getting to You?" https://www.linkedin.com/pulse/end-year-rush-getting-you-michelle-gibbings-nwcfc.

distance running: the runners usually maintain a moderate pace early in the race, conserving energy for a decisive final sprint in the last two hundred meters.[2] Similarly, the year-end period appears to provide the agents or contestants with an incentive that is distinct from other periods and drives them to intensify efforts as deadlines approach.

In this paper, we propose a complementary explanation for year-end aggressiveness based on tournament theory. A distinguishing feature of tournaments is that performance is evaluated on a relative, rather than absolute, scale (e.g., Lazear, 1995; Gibbons and Waldman, 1999; Chen, 2003). Consider a two-stage tournament where a contestant's final performance—and thus their likelihood of winning—depends on efforts in both periods. If interim performance is publicly observed after the first period, lagging contestants will act more aggressively in the second period (see Proposition 1 in Section 2 for theory; Chevalier and Ellison, 1997 and Genakos and Pagliero, 2012 for empirical evidence). An increased first-period effort has two opposing effects: it raises total performance (and winning probability) but also increases the chance of becoming the interim leader, which incentivizes opponents to escalate efforts in the second period. This adverse effect does not apply to second-period effort, as no further catch-up opportunities exist. Consequently, the marginal return to first-period effort is lower than that of second-period effort, leading to a lower equilibrium effort level in the first period. Note that our study does not aim to provide a unified theory of year-end rush (as the distinct explanations that have been provided in the literature are all plausible) but rather to complement existing explanations to enrich the understanding of this phenomenon.

We develop a canonical two-period tournament model with two competitors, where interim performances are publicly observed after the first period. Our analysis demonstrates that: (i) the lagging competitor in the first period exerts greater effort than the leader in the second period (the catching-up effect), and that (ii) competitors strategically reduce first-period effort to mitigate this effect, resulting in what we term the year-end rush phenomenon. While presented in a two-period framework, our core logic extends to multi-period settings: since the catching-up effect does not exist beyond the final period, the marginal return on effort (and therefore effort level) peaks in the terminal period. Furthermore, in the generalized n-contestant case, a competitor's second-period effort increases with their interim performance rank. This yields our key

[2] For those entering the 1,600-meter races, wikiHow offers tips to the runners to moderate and cruise the first 3 laps, gradually increasing their speed in the last lap, in order to "push your speed to the limit in the last 200m." https://www.wikihow.com/Run-a-1600-M-Race. Although the "last-200-meter rush" is somewhat different from the year-end rush, as one pertains to space and the other to time, the rationale behind them is the same.

theoretical prediction: a monotonic positive relationship between interim performance rank and the magnitude of the year-end rush.

We empirically test our theoretical predictions using data on Chinese patent applications. The Chinese context is ideal for our analysis due to a distinctive feature of its political system: political elites are not elected, but rather are career bureaucrats promoted through a hierarchical administrative structure. In this system, the Chinese government operates similarly to a large corporation with a multi-tiered hierarchy, where officials advance through the ranks based on performance. Promotion within this system—often referred to as "career concerns" in the literature (e.g., Holmström, 1999)—is widely understood as a tournament, with performance assessed on a relative rather than absolute basis (see, e.g., Lazear, 1995; Gibbons and Waldman, 1999; Chen, 2003). The promotion of Chinese officials is thus well-known to be based on relative performance (see citations of literature at the end of this section). Since the late 1980s, China's central government has increasingly emphasized the importance of scientific and technological advancement, issuing numerous directives to promote patent acquisition (see Section 3). Given the central role of relative performance in bureaucratic promotion (as discussed in Section 3), and the prioritization of innovation outcomes by the central government, it is plausible that inter-city competition over patenting constitutes a tournament structure aligned with our theoretical framework.[3]

Our theory has two key empirical implications for Chinese patent applications. First, there should be a prevalent year-end rush of patent applications across Chinese cities.[4] Second, and more crucially, when ranking cities by their relative interim patent registration performance within their respective provinces, we expect to find a monotonic positive relationship between a city's performance rank and the intensity of its year-end patent filing surge. Specifically, cities with lower interim rankings should demonstrate more aggressive year-end patent filing behavior.[5] Using city-level patent application data from China (1985-2019), we first confirm that the year-end filing surge, previously documented by Sun et al. (2021) at the national level, is equally prevalent at

[3] Chinese cities are the main driver of economic development in China, and the competition between Chinese cities is fierce. The cities in China's economic development are considered to be so important that Keyu Jin (2023) has coined the terminology "mayor economy."

[4] As we are aware, Sun et al. (2021) are the first to provide clear evidence of the year-end rush of patent applications in China. While they use national-level aggregate data, we use city-level data (see the discussions in Section 6). In a later paper, Park and Shin (2023) have identified the same phenomenon in South Korea.

[5] Given China's hierarchical political structure, the provincial governor regularly holds meetings with city mayors to review progress. The cities are thus well-informed of their relative positions within the province. Information regarding patent applications is available at: https://www.cnipa.gov.cn/. Additionally, cities typically release patent application data for the first three quarters. For examples, https://www.gd.gov.cn/gdywdt/dsdt/content/post_3683098.html

the city level. Furthermore, we observe a consistent monotonic relationship: cities ranking lower in provincial patent performance through September exhibit significantly stronger year-end filing surges. This pattern remains robust across alternative measures of interim performance and various definitions of rank.

However, our empirical analysis must address two key complications. First, China's patent growth target policy—introduced nationally in 2001 and adopted by provincial governments after 2005—overlaps with our study period. Since Sun et al. (2021) demonstrate that this policy drives year-end filing surges, we must disentangle whether the observed patterns reflect tournament incentives or policy effects. Second, while city officials face political career incentives, patents are ultimately filed by inventors rather than municipal governments. This raises the question of how officials' political objectives translate into inventors' filing behavior.

To address the first complication, we leverage two key institutional features of the growth target policy. First, growth targets represent absolute thresholds—once a city meets its target, the policy pressure on patent filings diminishes. In contrast, tournament competition operates through relative rankings, which continue to incentivize year-end filings regardless of target achievement. Second, the growth target policy was implemented nationally in 2001[6] and provincially after 2005. Since cities couldn't have responded to non-existent targets, any observed year-end surges before these dates (2001 nationally or 2005 provincially) must stem from tournament incentives rather than policy effects. Our empirical findings support both predictions.[7]

To address the second complication, we hypothesize that city officials incentivize inventors to file marginal innovations, which would otherwise remain unfiled due to their premature or lower quality, through subsidies and informal encouragement to contract with the patent agencies.[8] If true, the data should reveal two patterns: First, patent agencies account for a significantly higher share of filings in November and December compared to other months. Second, agency-filed patents during these year-end months exhibit substantially lower quality than non-agency filings, while no such quality gap exists in other months. Both are confirmed in the data.

The Chinese central government, to be sure, has long recognized the issue of low-quality patent proliferation and has implemented quality-control measures (see Section 3). However, the quantity, rather than quality, of patent applications persists as a critical

[6] Sun et al. (2023) also use 2000-2001 as a threshold for their DID regression.

[7] Note that South Korea, which does not have a national growth target policy, also exhibits a year-end surge in patent applications (Park and Shin, 2023).

[8] Incidentally, one of the authors received an advertisement from a patent agency offering a "bulk rate discount" for "helping with the year-end rush"!

performance metric for three possible reasons. First, patent quality typically takes years to assess - a timeframe that may exceed the tenure of government officials, weakening the incentive effects of quality-based metrics. Second, although performance measures can be based on the number of patents granted rather than filed, this approach also has its disadvantages. Similar to the substantial time taken to verify quality as mentioned above, invention patent applications usually take years to be granted (in our data, 966 days on average; almost three years). Third, performance based on granted patents is also associated with other types of inefficiency.[9] Consequently, despite its well-documented shortcomings, the quantity of patent applications continues to serve as a key performance indicator.

In sum, this paper provides a new perspective in explaining the year-end rush phenomenon as an equilibrium outcome of tournament competition among career-concerned contestants. Unlike the previous literature, this explanation is independent of specific rules in the organizations and applies to both the public and private sectors. Empirically, the theory not only explains China's year-end patent filing surge but may also account for similar patterns observed internationally (e.g., South Korea; Park and Shin, 2023). Furthermore, it might provide an alternative explanation for abundant evidence provided for similar regularity. The policy implication is that career concerns usually induce a tournament among agents in an organization, causing well-intentioned policies to be gamed through strategic competition. When evaluating a potential policy, it is imperative to foresee, and alleviate, the possible drawbacks induced by tournaments (Lazear, 1989; Rosen, 1985; Chen 2003).

This paper is related to three strands of the literature. First, it advances our understanding of the well-documented phenomenon of year-end surges in organizational activity across both public and private sectors (see citations at the beginning of this section). Second, this paper is related to the literature that investigates how career concern frames the agent’s incentives (see, e.g., Lazear, 1995, Gibbons and Waldman, 1999 and Lazear and Oyer, 2012 for surveys of literature), the behavior of agents facing a contest in static tournaments (see Konrad, 2009 for an excellent survey) and dynamic tournaments (Yildirim, 2005; Aoyagi, 2010; and Goltsman and Mukherjee, 2011),[10] and in particular the tournament nature of the Chinese bureaucracy.[11] Finally,

[9] Wei et al. (2023) provide fascinating evidence that highlights a “mild governmental failure” of Chinese patent policy using the number of patent granted as a performance measure.

[10] In particular, Goltsman and Mukherjee (2011) have shown that although revealing the interim performances to the contestants can provide stronger incentive in the latter periods, it also leads to other distortions. The optimal revelation policy has to balance the tradeoff of the two considerations.

[11] For example, Lü and Landry (2014); Yu et al. (2016); Li and Zhou (2005); Li et al. (2012, 2019) ; Wu et al. (2013); Xu (2011); Yao and Zhang (2015); Fang et al. (2022); and Xu et al. (2022).

it provides new insights into the evaluation of China's innovation policies and their unintended consequences.[12]

2. Theoretical Model

This section provides the theoretical background for the empirical investigation that follows. The model is stylized, and our purpose is to adopt a model that is as simple as possible to provide clear intuition behind the rationale for the year-end rush, and the extent to which it is affected by the relative interim performance.

We consider a tournament between two identical contestants that unfolds over two periods. In each period, contestants exert effort to improve their performance, which is subject to random shocks. Let Q_i^t denote the effort level of contestant i in period t, where $i = 1, 2$ and $t = 1,\ 2$. Since the empirical analysis in Section 4 focuses on patent applications, we will interpret the effort level as the number of patent applications in the empirical part. Each unit of effort incurs a constant cost $c > 0$. Exerting effort Q_i^t yields a gross benefit $V(Q_i^t)$. The net benefit for contestant i in period t is therefore $V(Q_i^t)\text{-}cQ_i^t$.

Each contestant's effort in a given period translates into a performance outcome for that stage. In the first period, given effort level Q_i^1, the contestant's interim performance is subject to a random shock $\tilde{\varepsilon}_i$, such that the observed performance at the end of period 1 is: $\widetilde{W}_i \equiv g(Q_i^1) + \tilde{\varepsilon}_i$, where $g' > 0$. Here, Q_i represents effort in the traditional tournament or contest theory, and $g(.)$ is the "production function" that maps effort into performance output. Since our analysis focuses on relative performance, we can, without loss of generality, normalize the production function such that $g(Q_i^1) = Q_i^1$. That is, performance is equal to effort plus noise.

The noise terms $\tilde{\varepsilon}_1$ and $\tilde{\varepsilon}_2$ are assumed to be independently and identically distributed, with probability density function $f(\cdot)$ and cumulative distribution function $F(\cdot)$. We further assume that $f(\cdot)$ is symmetric around zero, implying that the expected value of $\tilde{\varepsilon_i}$ is zero for each i. Let ε_i denote the realized value of $\tilde{\varepsilon}_i$, so that contestant i's realized interim performance at the end of period 1 is: $W_i \equiv Q_i^1 + \varepsilon_i$. The values of W_1 and W_2 are observed by both contestants at the end of period 1. Based on this interim performance, each contestant i chooses his effort level Q_i^2 for the second period. As in period 1, the performance in period 2 may also be subject to a random shock. However, since the contestants are assumed to be risk-neutral and the shock has an expected value of zero, the performance in period 2 is equal to the effort

[12] For example, Hu and Jefferson (2009); Prud'homme (2012); Li (2012); Hu et al. (2017); Wei et al. (2017b); Lin et al. (2021); Wu et al. (2022); Dang and Motohashi (2015); Dai and Wang (2024); and Eberhardt et al. (2017).

level. To simplify the analysis, and without loss of generality, we assume that the actual performance in period 2 is simply: $W_i^2 \equiv Q_i^2$.[13]

At the end of period 2, contestant i's total performance, denoted by Y_i, is determined by the sum of their interim performance and their second-period effort: $Y_i = W_i + Q_i^2$. The total performances Y_1 and Y_2 then determine the probability that each contestant wins the tournament. A contestant's total utility thus consists of two components. The first is the sum of the per period net benefit specified above, $V(Q_i^t)$-cQ_i^t. The second component reflects career concerns arising from the tournament structure, i.e., the winner receives a "reward" M, which captures the idea that the winning contestant enjoys a better prospect of future promotion, or gains a better reputation in their career — consistent with the notion of career concerns discussed Holmström (1999). The winning probability is captured by a contest success function, which defines the probability that contestant 1 wins as a function of total performance: $Prob(1\ wins) = P(Y_1, Y_2)$. Contestant 2's winning probability is then $1 - P(Y_1, Y_2)$.

The function $P(Y_1, Y_2)$ is assumed to be continuously differentiable. We make the following assumptions regarding the contest success function and utility function:

Assumption 1: (i) $P_1 > 0, P_{11} < 0, P_2 < 0$, and $P_{22} > 0$; (ii) $P(Y, Y') = 1 - P(Y', Y)$, $P_1(Y, Y') = -P_2(Y', Y)$; (iii) $P_{12} > 0$ when $Y_1 < Y_2$, and $P_{12} < 0$ when $Y_1 > Y_2$; (iv) $V' > 0$, $V'' < 0$, and $V''' > 0$; (v) $\lim_{Y_i \to \infty} P_i(Y_1, Y_2) = 0$, $c > M$, and $\lim_{Q \to 0} V'(Q) = \infty$.

Assumption 1(i) posits that a contestant's probability of winning increases with their own effort but at a decreasing marginal rate—i.e., the marginal effectiveness of effort diminishes. Assumption 1(ii) is a standard symmetry condition, requiring that contestants facing a symmetric environment possess identical winning probabilities and marginal effects from their efforts. Assumption 1(iii) introduces a strategic interdependence: when a contestant is behind in performance, the marginal effect of their effort—specifically, in terms of reducing the opponent's marginal return to effort—increases; conversely, when leading, this marginal effect decreases.[14] The first two components in Assumption 1(iv) represent the standard features of the utility function: increasing and concave benefits of effort and linear costs. The additional condition $V''' > 0$ reflects what Collier (2008, Chapter 2) refers to as prudence. This

[13] The possible random consequence of Q_i^2 on performance can be captured by the contest success function, to be specified shortly.

[14] This assumption is motivated by the long-distance running analogy mentioned in Section 1: The more competitors ahead of a runner, the better he can assess his current status--such as behind whom he is and by how far – and adjusts his pace according. Conversely, the further one is ahead, the less information he has for this assessment.

curvature assumption is satisfied when the utility function exhibits constant or decreasing absolute or relative risk aversion (see Jehle and Reny, 2011, Chapter 2). Lastly, Assumption 1(v) is to guarantee an interior solution for the optimal effort level.[15]

In period 1, contestant *i* determines the value of Q_i^1 to maximize his total utility. At the end of period 1, $\tilde{\varepsilon}_1$ and $\tilde{\varepsilon}_2$ (and therefore $\widetilde{W}_1$ and $\widetilde{W}_2$) are realized. Based on the observed interim performances W_1 and W_2, each contestant *i* then chooses Q_i^2. Following the convention of backward induction in multi-period optimization, we first solve for second-period equilibrium. The optimization problem for contestant *i* is

$$\max_{Q_i^2} V(Q_i^2) - cQ_i^2 + Prob(i\ wins)M.$$

The solution depends on realized interim performance W_1 and W_2, through the winning probability, so Q_i^2 is a function of both W_1 and W_2. The first-order conditions for Q_i^2 are:

$$V'(Q_1^2) - c + \frac{\partial P(Y_1, Y_2)}{\partial Q_1^2} M = 0, \text{and}$$
$$V'(Q_2^2) - c - \frac{\partial P(Y_1, Y_2)}{\partial Q_2^2} M = 0. \tag{1}$$

Since the optimal value of Q_i^2 depends on W_1 and W_2, we denote it as $Q_i^2(W_1, W_2)$. The equations in (1) imply:

$$V'(Q_1^2(W_1, W_2)) + P_1(Y_1, Y_2)M = V'(Q_2^2(W_1, W_2)) - P_2(Y_1, Y_2)M.$$

Suppose $W_1 > W_2$, meaning contestant 1 has a higher interim performance. If $Q_1^2(W_1, W_2) \geq Q_2^2(W_1, W_2)$, then by the concavity of $V(\cdot)$ we know that $V'(Q_1^2(W_1, W_2)) \leq V'(Q_2^2(W_1, W_2))$, implying $P_1(Y_1, Y_2) \geq -P_2(Y_1, Y_2)$. Furthermore, since $Y_i = W_i + Q_i^2$ and $W_1 > W_2$, it follows that $Y_1 > Y_2$, which in turn implies that $P_1(Y_1, Y_2) < P_1(Y_2, Y_2) = -P_2(Y_2, Y_2) < -P_2(Y_1, Y_2)$, where the first inequality is from $P_{11} < 0$, the first equality from symmetry, and the second inequality from the assumption that $P_{21} < 0$ when $Y_1 > Y_2$. This contradicts the earlier conclusion that $P_1(Y_1, Y_2) \geq -P_2(Y_1, Y_2)$. Therefore, when $W_1 > W_2$, it must be that $Q_1^2(W_1, W_2) < Q_2^2(W_1, W_2)$. Similarly, if $W_2 > W_1$, then $Q_2^2(W_1, W_2) < Q_1^2(W_1, W_2)$. In other words,

[15] Assumption 1(v) is actually far stronger than necessary to guarantee an interior solution. Since the theory mainly serves to provide intuition and to motivate the empirical part, we deliberately choose a strong sufficient condition so that we do not need to go through the details of the first- and second-order conditions.

the contestant lagging in interim performance exerts greater effort than the opponent in the second stage.[16]

Proposition 1 *(The Catching-Up Effect) If i has a higher interim performance, i.e.,* $W_i > W_j$*, then his second-period effort level (quantity) is lower, i.e.,* $Q_i^2 < Q_j^2$.

Although $W_i > W_j$ implies $Q_j^2 > Q_i^2$, the value of Q_j^2 cannot be greater than Q_i^2 by so much so that the final performance is reversed, i.e., $Y_j > Y_i$. For example, suppose $W_1 > W_2$ yet $Y_2 > Y_1$. By Proposition 1, $V'(Q_1^2) > V'(Q_1^1)$ implies $P_1(Y_1, Y_2) < -P_2(Y_1, Y_2)$. However, the contest success function properties yield $P_1(Y_1, Y_2) > P_1(Y_1, Y_1) = -P_2(Y_1, Y_1) > P_1(Y_1, Y_2)$, where the first inequality is from $P_{12} > 0$, the first equality from symmetry, and the second inequality from $P_1(Y_1, Y_2) < -P_2(Y_1, Y_2)$. This fact has an important implication for our proof: Although we have not yet solved for the first-period equilibrium, the symmetry of the initial environment in the first period obviously implies that $Q_i^1 = Q_j^1$. It then follows that $W_i > W_j$ if and only if $\varepsilon_i > \varepsilon_j$, which in turn guarantees that $Y_i > Y_j$ in equilibrium: a contestant who is lucky in the first stage has a greater chance of winning, despite that one who lags in interim performance will put in more effort than a competitor in the second stage. In other words, the relative ranking between W_i's is identical to that between final performances Y_i's.

While Proposition 1 is established for the two-contestant case, Proposition A1 in Appendix 1 demonstrates that analogous assumptions extend this result to the general case. This extension yields a robust prediction: a contestant's second-period effort level decreases monotonically with their interim performance ranking. In our empirical setting, this implies a monotonic relationship between a city's provincial rank in interim patent performance and the intensity of its year-end patenting surge. The theoretical prediction suggests that lower-ranked cities will exhibit more pronounced year-end rushes than their higher-ranked counterparts within the same province.

Before we go into the first stage's solution, we need certain comparative statics results from the second stage. The second-order conditions for Q_1^1 and Q_2^1 are

$$V''(Q_1^2) + P_{11}M \equiv \Delta_1 < 0,$$

$$V''(Q_2^2) - P_{22}M \equiv \Delta_2 < 0, \text{ and}$$

[16] One might reason that a contestant that lags far behind, having little chance of winning, might as well give up in the second stage. This is not correct. First, effort still yields benefit $V(Q_i^2) - cQ_i^2$. Second, and most important, the optimal effort level is determined by its marginal benefit. For example, assume that a contestant has a winning chance of 1/1000, and that one more unit of effort increases it to 1/10, which is still tiny. However, the increase in the winning probability, and the marginal return of effort, is substantial. Alternatively, assume that one has a substantial winning chance of 1/3, but an additional unit of effort increases the winning probability by only 1/1000. The former case provides a much greater incentive for effort than the latter, despite its much smaller winning chance.

$$\Delta_1\Delta_2 + P_{12}P_{21}M^2 \equiv \Delta > 0.$$

Define $X_{ij} \equiv \partial Q_i^2/\partial Q_j^1$. The value of X_{ij} indicates how j's first-period effort level affects that of i in the second period, a value crucial for the subsequent results. From the first-order condition, we know that

$$X_{11} = \frac{-P_{21}P_{12}M^2 + \Delta_2 P_{11} M}{\Delta}, \text{and}$$

$$X_{22} = \frac{-P_{21}P_{12}M^2 + \Delta_1 P_{22} M}{\Delta}$$

Since $\Delta > 0$, $\Delta_2 < 0$, $P_{12} = P_{21}$ and $P_{11} < 0$, we know that $X_{11} < 0$. Similarly, $\Delta_1 < 0$, $P_{22} > 0$, so that $X_{22} < 0$.

What will be of greater importance for our purpose later are the values of

$$X_{21} = \frac{P_{21}V''(Q_1^2)M}{\Delta}, \text{and}$$

$$X_{12} = \frac{-P_{12}V''(Q_2^2)M}{\Delta}.$$

The equation for X_{12} implies that $X_{12} > (<)0$ if $P_{12} > (<)0$. Assumption 1(iii) then implies that $X_{12} > (<)0$ if $Y_1 < (>)Y_2$ or, equivalently, $W_1 < (>)W_2$. Similarly, $X_{21} < (>)0$ if $P_{12} > (<)0$, or, equivalently, $Y_1 < (>)Y_2$ or, again equivalently, $W_1 < (>)W_2$. Whether a contestant's second-stage effort increases with the opponent's first-stage effort depends on whether he leads or lags in terms of interim performance.

We now characterize the first-period equilibrium. A contestant's first-period effort choice involves two countervailing effects: (1) a direct positive effect on both interim performance and ultimate winning probability, and (2) an indirect strategic effect whereby stronger interim performance induces more aggressive second-period responses from opponents (by Proposition 1). Crucially, second-period effort carries no such strategic response, as the game terminates thereafter. This asymmetry implies that the marginal return to first-period effort is strictly lower than to second-period effort, implying that equilibrium effort is strictly lower in the first period than in the second.

This argument requires one important qualification. Contestants begin symmetrically in the first period but face asymmetric interim performances in the second period. Consequently, the comparison of effort levels across periods depends on the realized values of W_1 and W_2. For example, if contestant *i* is very lucky in the first period, in that ε_i is very large, then it is impossible for his second-period effort to be greater than the first by Assumption 1(v). However, given the symmetry of noise and identical first-period efforts, each contestant is equally likely to be ahead or behind after the first period. The catching-up effect therefore implies that second-period effort is, *on average*, higher than first-period effort. In equilibrium, we thus expect that $Q_i^1 < E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2} Q_i^2(\widetilde{W}_1, \widetilde{W}_2)$. To show this, we solve for the first-period equilibrium. At the beginning of the first period, the expected utility of *i* is:

$$U_i = V(Q_i^1) - Q_i^1 c + E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}\left[V(\tilde{Q}_i^2(\widetilde{W}_1, \widetilde{W}_2)) - \tilde{Q}_i^2(\widetilde{W}_1, \widetilde{W}_2)c + Prob(i\ wins)M\right].$$

The first-order conditions for Q_1^1 and Q_2^1 are:

$$V'(Q_1^1) - c + E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}[(V'(Q_1^2) - c)X_{11} + (P_1(1 + X_{11}) + P_2 X_{21})M] = 0, \text{and}$$

$$V'(Q_2^1) - c + E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}[(V'(Q_2^2) - c)X_{22} - (P_1 X_{12} + P_2(1 + X_{22}))M] = 0.$$

As mentioned earlier, since the two contestants are symmetric in the first period, it is obvious that the equilibrium quantity must be that $Q_1^1 = Q_2^1$. Recall that the first-order conditions for Q_1^2 and Q_2^2 are

$$V'(Q_1^2) - c + P_1 M = 0, \text{and}$$

$$V'(Q_2^2) - c - P_2 M = 0.$$

Therefore, the first-order conditions for Q_1^1 and Q_2^1 reduce to

$$V'(Q_1^1) - c + E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}[P_1 + P_2 X_{21}]M = 0, \text{and}$$

$$V'(Q_2^1) - c - E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}[P_2 + P_1 X_{12}]M = 0.$$

They in turn imply that, for *i*=1,

$$Q_1^2 = v(c - P_1 M), \text{and}$$

$$Q_1^1 = v[E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}(c - (P_1 + P_2 X_{21})M)],$$

where $v \equiv (V')^{-1}$, so that $v' < 0$. In addition, the assumption that $V''' > 0$ implies that $v'' > 0$. If we can show that $E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}(P_2 X_{21}) < 0$, then

$$E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}(Q_1^2) = E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}[v(c - P_1\, M)] > v\left(E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}(c - P_1\, M)\right)$$

$$> v(E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}(c - (P_1\ + P_2 X_{21})M)) = Q_1^1.$$

The first inequality above comes from $v'' > 0,$ and the second inequality from the fact that $v' < 0.$ This implies contestant 1's second-period effort is greater than that of the first period. Similarly, if we can show that $E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}(P_1 X_{12}) > 0$, then $E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}(Q_2^2) > Q_2^1$. They are proved in the following lemma.

Lemma 1 $E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}(P_2 X_{21}) < 0$ *and* $E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}(P_1 X_{12}) > 0$.

Proof: As mentioned earlier, because $Q_1^1 = Q_2^1$ in the equilibrium, $Y_1 > Y_2$ if and only if $\varepsilon_1 > \varepsilon_2$. In this case $P_{12} < 0$ by Assumption 1(iii), and thus $X_{12} < 0$ by the comparative statics results derived earlier. Conversely, $\varepsilon_1 < \varepsilon_2$ implies that $P_{12} > 0$, and thus $X_{21} < 0$. Therefore,

$$E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}(P_2 X_{21}) = E_{\tilde{\varepsilon}_1 < \tilde{\varepsilon}_2}[P_2 X_{21}] + E_{\tilde{\varepsilon}_1 \geq \tilde{\varepsilon}_2}[P_2 X_{21}]$$

$$= \int_{-\infty}^{+\infty}\int_{-\infty}^{\tilde{\varepsilon}_2} P_2 X_{21} dF(\tilde{\varepsilon}_1) dF(\tilde{\varepsilon}_2) - \int_{-\infty}^{+\infty}\int_{-\infty}^{\tilde{\varepsilon}_1} (-P_1 X_{12}) dF(\tilde{\varepsilon}_2)\, dF(\tilde{\varepsilon}_1) +$$

$$\int_{-\infty}^{+\infty}\int_{-\infty}^{\tilde{\varepsilon}_1} (P_2 X_{21} - P_1 X_{12}) dF(\tilde{\varepsilon}_2)\, dF(\tilde{\varepsilon}_1)$$

Due to the symmetry of the two contestants, as well as that of $\tilde{\varepsilon}_1$ and $\tilde{\varepsilon}_2$, the first two terms above cancel each other out.

Therefore,

$$E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}(P_2 X_{21}) = \int_{-\infty}^{+\infty}\int_{-\infty}^{\tilde{\varepsilon}_1} (P_2 V''(Q_1^2) + P_1 V''(Q_2^2)) \frac{P_{12} M}{\Delta} dF(\tilde{\varepsilon}_2) dF(\tilde{\varepsilon}_1).$$

When $Y_1 > Y_2$ (or equivalently, $\varepsilon_1 > \varepsilon_2$), we know that $P_{12} < 0$ by Assumption 1(iii). Furthermore, $Q_1^2 < Q_2^2$ by Proposition 1, which further implies that $0 > V''(Q_2^2) > V''(Q_1^2)$ by the assumptions that $V''' > 0$ and $V'' < 0$. Recall that we have already shown in the proof of Proposition 1 that $0 < P_1 < -P_2$, so it follows that $\left(P_2 V''(Q_1^2) + P_1 V''(Q_2^2)\right) > 0$ and $\left(P_2 V''(Q_1^2) + P_1 V''(Q_2^2)\right) \frac{P_{12} M}{\Delta} < 0$. This implies that $E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}(P_2 X_{21}) < 0$. A similar procedure can show that $E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}(P_1 X_{12}) > 0$. QED

Using Lemma 1, we have the following proposition:

Proposition 2 *(Year-End Rush) The expected equilibrium effort level in the second stage is greater than the equilibrium first-stage effort:* $E_{\tilde{\varepsilon}_1,\tilde{\varepsilon}_2}(Q_i^2(\widetilde{W}_1,\widetilde{W}_2)) > Q_i^1$.

It is important to note that Propositions 1 and 2 hold exactly because of the career concern term $P(\cdot)M$ in U_i. In the absence of this term, Q_i^2 will not be a function of W_1 and W_2, and there will be neither a catching-up effect nor a year-end surge, as in that case $Q_i^1 = Q_i^2$.

Proposition 2 provides the theoretical foundation for understanding year-end rushes. The mechanism operates through two key channels: (i) only final-period effort escapes the strategic dampening effect of opponents' catching-up responses, and (ii) equilibrium behavior consequently concentrates higher effort in the terminal period. This insight aligns with Carpenter et al. (2010), who demonstrate that tournament participants reduce output when anticipating opponents' strategic undercutting (through sabotage in their framework, analogous to our second-period effort response).

Our analysis focuses on a two-contestant, two-period model, as extending it to a general *T*-period framework would introduce intractable dynamic complexities due to asymmetric interim performances in all but the initial period. While the dynamics of intermediate periods ($t = 1,..., T$-2) lie far beyond the scope of this paper, our core insight about year-end rushes remains valid: the terminal period uniquely lacks catching-up incentives, making effort most effective on average in the final stage. This prediction finds support in the strategic behavior of medium- or long-distance runners, who typically conserve energy for a final sprint. Moreover, Proposition A1 in Appendix 1 demonstrates that Proposition 1 generalizes to the *n*-contestants case. This extension implies a monotonically increasing relationship between a contestant's rank order in interim performance and his end-period effort level—a result that directly informs our empirical analysis of year-end rushes in multi-agent settings.

3. Institutional background

In this section, we provide two institutional backgrounds for our empirical investigation, one regarding the nature of promotion in the Chinese bureaucracy, and the other regarding the Chinese patent policy.

3.1 China's Political Structure

China's administrative system operates through a strict five-tier hierarchy: the central government, provinces, cities, counties, and townships/villages. Each level represents both a geographical subdivision and an administrative subunit of the level above. A key feature of this system, implemented in 1984, is the "one-level-down" appointment mechanism. Under this framework, the central government directly appoints provincial leaders, who in turn evaluate and appoint municipal-level leaders, creating a clear chain of accountability and control (Lieberthal, 1995).

With this structure, the Chinese administrative system operates akin to a large corporation (see Jin, 2023), where political elites are career bureaucrats promoted through a centralized personnel management system rather than electoral processes. Crucially, promotions are determined by relative (rather than absolute) performance, effectively creating a rank-order tournament (Lazear, 1995; Gibbons and Waldman, 1999; Chen, 2003). Extensive research has documented this tournament-style promotion system for Chinese officials (Li and Zhou, 2005; Xu, 2011; Lü and Landry, 2014; Yao and Zhang, 2015; Yu et al., 2016; Li et al., 2012, 2019; Fang et al., 2022; Xu et al., 2022). Officials are evaluated on multiple dimensions including political loyalty, experience, innovation, and economic performance. This system creates strong incentives to prioritize easily measurable targets, particularly economic growth (Li and Zhou, 2005; Xu, 2011; Yao and Zhang, 2015). Following the 1985 Patent Law, scientific and technological progress became a top government priority, making innovation performance an increasingly important criterion in official evaluations.

As a legacy of the planned economy, the government has implemented comprehensive Five-Year Plans since 1953 to guide economic and social activities through a top-down framework, highlighting many critical targets that serve as guidelines for development over the upcoming five years.[17] These plans establish key performance indicators across multiple domains, including GDP growth, fiscal expenditure, and innovation outputs - with patent-related targets being particularly relevant to our study. While the national-level targets for patent filing were set in 2001, provincial governments then adapted based on national goals and local conditions (see the next subsection). Although these targets are not mandatory, they are taken seriously, exerting significant influence on bureaucratic behavior (Li et al., 2019).

In China, the cities are the main drivers of economic and technological progress. Their pivotal role in economic development has led scholars like Jin (2023) to characterize China's economy as a "mayor's economy." Within this hierarchical system, municipal officials compete fiercely for career advancement, with their relative performance within provincial rankings serving as a key determinant of success. This

[17] To be sure, while the Five-Year Plans helped setting clear national development agendas, the top-down appoach has resulted in side-effects and distortions. For example, the sex-ratio parity caused by the one-child policy has induced strong status competition among eligible men in terms of house possession and savings decision (Wei and Zhang, 2011; Wei et al. 2017a). Xu et al. (2022) also provides evidence of performance manipulation among local officials.

tournament-style competition among city officials motivates our use of city-level data in the empirical analysis.[18]

3.2 China's Patent Policy

During the late 1980s, the Chinese government began to view innovation as being crucial for future economic development. As with many national priorities, the government undertook substantial administrative efforts to promote innovation. The central government issued a series of policies aimed at strengthening intellectual property protections and encouraging patent acquisition, including measures such as tax incentives and direct subsidies. In 2001, following the adoption of the National 10th Five-Year Plan for Patenting, the National Intellectual Property Administration issued the first directive to explicitly set an annual patent growth target—14 percent.[19] Subsequently, local governments at the provincial level introduced their own patent growth targets, most of which emerged during 2005–2006 and typically (around 60% of provinces) aimed for annual growth rates of 10 to 15 percent (15% of the provinces have set 20%). The specific growth targets and their years of issuance for each province are presented in Table A1 in Appendix 2.

However, well before the 2001 directive that introduced explicit growth targets, the central government had already issued numerous documents emphasizing the importance of scientific and technological progress as well as intellectual property protection. For instance, in 1985—when the first Chinese Patent Law came into effect—the Chinese Patent Office released a regulation that included several provisions offering subsidies, which included several provisions offering subsidies for patent filing fees.[20] Similarly, both the 1996 *Government Work Report*[21] and the *Ninth Five-Year Plan Outline Report*[22] highlighted the importance of "strengthening intellectual property protection and protecting patent inventions".

Following the central government's initiatives, local authorities also took proactive steps to promote patent protection and encourage patent acquisition. For example, Guangdong Province issued relevant regulations on scientific and technological

[18] It is important to note that, unlike in many other countries, in China the cities are geographically a complete partitions of the provinces, and are one level directly in subordination to the provinces.

[19] https://www.cnipa.gov.cn/art/2001/10/31/art_65_11333.html

[20] *Implementing Regulations for the Reduction or Postponement of Payment by Individual Applicants*. https://www.pkulaw.com/en_law/fc1328e1dfdc5d80bdfb.html. As another example, see *The Decision on Further Strengthening Intellectual Property Protection Work* issued by the State Council in 1994. https://www.gd.gov.cn/zwgk/gongbao/1994/17/content/post_3357270.html

[21] https://www.gov.cn/test/2006-02/16/content_201115.htm

[22] The complete title of the document is *Report on the Outline for the Ninth Five-Year Plan for National Economic and Social Development* and the *Program for Long-Term Objectives through the Year 2010.* https://www.ndrc.gov.cn/fggz/fzzlgh/gjfzgh/200709/P020191029595686994247.pdf

progress in 1995, offering incentives for innovation.[23] Taken together, these developments suggest that local officials—particularly at the city level—were well aware of the importance of patent performance in their evaluations even before the issuance of the 2001 national directive.

As with many well-intentioned government policies, China's efforts to promote innovation have also produced unintended—and at times adverse—consequences, as documented in the existing literature (Hu and Jefferson, 2009; Hu et al., 2017; Eberhardt et al., 2017; Sun et al., 2021; Hsu et al., 2021; Wei et al., 2023). One such consequence of the patent growth targets is that, although the policy successfully stimulated a dramatic increase in patent applications, many of the resulting patents were of low quality. A striking example is the "year-end rush" of patent filings identified by Sun et al. (2021), which shows a clear surge in patent applications during November and December each year. Notably, these late-year filings tend to be of substantially lower quality. Sun et al. (2021) attribute this phenomenon to local governments that, anticipating failure to meet annual growth targets around September or October, respond by pushing through low-quality patent applications that would likely not have been filed in the absence of such targets. While this explanation is plausible, it presents certain inconsistencies when considered alongside the broader data and institutional context. We explore these issues in detail in Section 6.

To be sure, the central government has not been unaware of the surge in low-quality patents and has implemented a range of measures to address the issue. For example, in the *National Patent Development Strategy* (2011–2020),[24] the China National Intellectual Property Administration (CNIPA) emphasized the metric of "invention patents owned per million population" as a target, rather than the "application growth rate." This shift signaled an intention to curb the indiscriminate pursuit of patent filings. Similarly, CNIPA released a strategic plan (2013)[25] and opinions on improving patent quality,[26] both outlining initiatives to enhance patent quality. These policy documents sought to raise the examination threshold and reorient funding policies to prioritize quality over quantity. As noted in the Introduction, however, despite these central efforts,

[23] *Regulations on the Promotion of Scientific and Technological Progress in Guangdong Province.* https://www.gd.gov.cn/zwgk/wjk/zcfgk/content/post_2532330.html. Similarly, in 1999, Shanghai issued the *Measures for Funding Shanghai Patent Application Fees* and *Agency Fees and the Rules for Implementing Shanghai's Patent Application Funding.* https://ipkey.eu/sites/default/files/ipkey-docs/2022/Study%20on%20Utility%20Model%20Patent%20System%20of%20China_CN.pdf

[24] https://www.cnipa.gov.cn/art/2010/11/18/art_65_11353.html

[25] *Promotion Plan for the Implementation of the National Intellectual Property Strategy.* https://www.cnipa.gov.cn/art/2015/3/9/art_398_110779.html

[26] *Several Opinions of the State Intellectual Property Office on Further Improving the Quality of Patent Applications.* https://www.cnipa.gov.cn/art/2013/12/18/art_564_146103.html

the sheer number of patent applications has continued to serve as a key indicator of innovation performance in the evaluation of local officials.

4. Data and Motivating Facts

4.1 Data

The patent application data are obtained from China's State Intellectual Property Office (SIPO) and cover the full population of patent applications submitted between 1985 and 2019. The dataset includes detailed information on each application, such as the application number, filing date, city/province, technological classification, patent title, assignee, inventor, and patent agency. China's patent system recognizes three types of patents: invention patents, utility model patents, and design patents.[27] In total, the dataset comprises 26,380,261 patent applications, including 9,218,736 invention patents, 11,570,382 utility model patents, and 5,591,143 design patents.

To analyze monthly trends in patent applications, we aggregate the data at the city-year-month level, summing the total number of patent filings for each city in each year and month. We also aggregate the data to the city-year level. We then have 122,475 city-year-month observations and 9,267 city-year-level observations across 358 cities from 27 provinces and 4 province-level municipalities during the sample period. Summary statistics for the provinces and cities, including the average number of yearly patent applications, are presented in Table 1.

Following standard practice in the literature, we use forward citations—measured over a three- or five-year window—to proxy for patent quality. For example, the three-year forward citation count for a patent filed on January 5, 2010, refers to the total number of citations it received by January 5, 2013. Given that our citation data span from 1985 to 2016, we restrict the calculation of forward citations accordingly: up to 2013 for the three-year measure and up to 2011 for the five-year measure. Summary statistics for these measures are reported in Panel A of Table 2.[28]

4.2 Motivating Facts of the Year-End Rush in Patent Applications

Since the basic unit of our empirical analysis is at the city level, we first verify whether the year-end rush regularity identified in Sun et al. (2021), which uses national

[27] Invention patents protect innovative technical solutions or improvements in products or processes, requiring a high level of innovation. Utility model patents focus on the structural and shape aspects of mechanical structures with less stringent innovation requirements. Design patents cover new designs, shapes, patterns, or colors that have aesthetic appeal and are fit for industrial application.

[28] Our data only contain citations of the invention patents, which is the main concern of the Chinese government. Therefore, in the regressions that are concerned with patent quality, we mean the quality of the invention patents.

aggregate data,[29] persists in our city-year-month level data. Specifically, we estimate the following monthly trend regression:

$$Patent_{cmt} = \alpha_0 + \sum_{m\in\{1,\cdots,12\},m\neq 7} \beta_m \cdot Month_{ct}^{m} + \mu_c + \mu_t + \varepsilon_{ct}, \tag{2}$$

where $Patent_{cmt}$ denotes the proportion of patent applications filed by city c in month m, relative to the total filed in year t. $Month_{ct}^{m}$ is a dummy variable that equals 1 for month m and 0 otherwise. July is taken as the reference month in the regression. μ_c and μ_t respectively represent city-fixed effects and year-fixed effects, and ε_{ct} is the error term. (The summary statistics are presented in (A) of Table 2.)

The regression results are depicted in Figure 1. There is a significant surge in patent applications in November and December. There is also a noticeable dip at the beginning of the year, specifically in January and February.[30] This monthly trend pattern is consistent across all three types of patents and is broadly consistent with the national-level data in Sun et al. (2021).[31]

To account for the overall upward trend in patent applications, we conduct a robustness check to ensure that the observed year-end surge is not merely a reflection of the time trend. Specifically, we construct a pseudo-year that includes the last two months of fiscal year t and the first ten months of fiscal year $t+1$, and re-estimate Eq. (2) using the monthly share of patent applications within this pseudo-year as the outcome variable. As illustrated in Figure A1 (Appendix 3), patent applications in November and December of year t remain significantly higher than in the subsequent months of year $t+1$. These findings confirm that the observed pattern reflects a genuine year-end rush in patent filings, rather than a mechanical artifact of temporal trends.

5. Empirical Strategy and Baseline Model

5.1 Definitions of Key Variables

The literature, particularly Sun et al. (2021), has attributed the year-end rush to the government's growth target policy. The underlying rationale is that cities, upon realizing around September or October that they are falling short of their annual patent growth targets, accelerate patent applications in the final two months of the year. In other words, a weaker interim performance relative to the target prompts a last-minute

[29] Sun et al. (2021) use only invention patents data in their estimation.

[30] Our data show a stronger surge in November than Sun et al. (2021). The Jan/Feb deep trough is caused by the long Chinese New Year, which generally lies in the end of January and the beginning of February, and generally lasts for 10-14 days. There is also a discernible decrease during October. Again, this is mainly due to the October 1 National Day, which usually results in a 7-day holiday.

[31] Similar to Sun et al. (2021), our city-level data also show a decline in quality for patents applications filed in November and December. On this, see Appendix 8.

push to meet targets. If this explanation holds, there should be a negative relationship between a city's interim performance and the extent of its year-end patent rush.

Alternatively, our theoretical model also predicts that the year-end surge in patent applications can be a consequence of tournaments based on relative performance. The motivations underlying growth targets and tournament behavior differ in important ways. The former reflects an effort to meet an absolute benchmark and is independent of other cities' performance. A tournament, by contrast, relies on relative comparison. In such a setting, even a city that has already met its growth target may still exhibit a year-end surge in filings—this is a natural consequence of tournament incentives (Proposition 2). Moreover, the further a city lags in its interim performance ranking relative to other cities within the same province, the greater the intensity of its year-end rush (Proposition A1). Accordingly, we hypothesize a monotonically increasing relationship between a city's rank order in interim performance within its province and the extent of its year-end patent rush.

We define three key variables in accordance with our empirical strategy. First, the extent of the year-end rush for city *c* in year *t*, denoted as YER_{ct}, is defined as the ratio of the total number of patents filed in the last two months of year *t* to the total number filed throughout the entire year. The greater its value, the greater the extent of the city's year-end rush in that year. Second, to measure a city's interim performance, we define the *interim target achievement rate* for city *c* in year *t*, denoted as $ITAR_{ct}$, as the ratio of the city's total number of patent applications in the first nine months of year *t* to that filed in the same period of year *t-1*. Thus, $ITAR_{ct}$ captures the interim growth rate in patent filings and reflects how far a city is ahead of or behind its annual target by the end of September. A higher value of $ITAR_{ct}$ suggests that the city is more likely to meet its full-year target.[32] We use September, rather than October, as the cutoff for calculating $ITAR_{ct}$ for two reasons. First, as will be discussed in Section 7, the year-end rush often requires administrative work and it takes time. If a city assesses its progress only at the end of October, it may lack sufficient time to implement filing strategies during November. Second, since *YER* is measured for the last two months, if *ITAR* is calculated up to October, it might introduce a possible (but presumably weak) correlation between *YER* and *ITAR,* especially if the city's monthly trend of applications follows a similar pattern every year.[33]

[32] There might be a concern that the extent of the year-end rush (*YER*) may be correlated with the target achievement rate (*ITAR*) due to the way in which the variables are constructed. However, this is not the case. Let x_t be a city's total number of patents filed in the first nine months of year *t*, and y_t be the total number of patent applications filed in the last two months. Then, $ITAR_t = x_t/x_{t-1}$, while $YER_t = y_t/(x_t + y_t + October\ filings)$. The two measures are unlikely to be significantly correlated.

[33] Although we will show that there exists a negative relationship between *YER* and *ITAR*, it is due to causality, and not the definitions of the two variables.

Finally, we define the *pure rank* of a city, denoted by PR_{ct}, as the rank order of city c in its $ITAR_t$ within its province. However, a challenge in using pure rank is that provinces differ in the number of cities they contain—some have as many as 21 cities, while others have as few as 5 (see Table 1). As a result, a city ranked 10th in one province may have no counterpart in another. To address this issue and ensure comparability across provinces, we assign cities to *quintile ranks* instead.[34] Specifically, cities are grouped into quintiles based on their rank order within their province. Let a province have z cities. Then, a city is assigned to the first quintile if its rank order is less than or equal to Ceil(0.2z), where Ceil(x) is the ceiling of x—that is, the smallest integer greater than or equal to x. Cities with ranks between Ceil(0.2z)+1 and Ceil(0.4z) are placed in the second quintile, and so on. This quintile-based ranking ensures that every province has five rank categories, regardless of its size. Accordingly, we define $Rank_{ct}$ as the quintile rank of city c in year t, based on its interim performance $ITAR_{ct}$ relative to other cities in the same province. A higher value of $Rank_{ct}$ indicates that the city is lagging further behind in its interim performance. This variable captures a city's relative interim performance at the end of September. If career concerns motivate local officials to boost patent counts, then, according to Proposition A1, cities that rank lower (i.e., larger values of $Rank_{ct}$) should display a more pronounced year-end rush.[35] To relate this empirical framework to the theory presented in Section 2, we consider Period 1 in the model as spanning January through September, and Period 2 as comprising November and December. The effort level in the theory corresponds to the number of patent applications filed. The summary statistics for the three variables are presented in Panel (B) of Table 2.

5.2 Baseline Model and Regression Results

We estimate the following baseline model to investigate the influences of *ITAR* and *Rank* in the same regression:[36]

$$YER_{ct} = \alpha_0 + \alpha_1 ITAR_{ct} + \sum_{n=1,2,\cdots,5,n\neq 3} \beta_n \cdot Rank_{ct}^n + \mu_c + \mu_t + \varepsilon_{ct}, \tag{3}$$

where $Rank_{ct}^n$ is a dummy variable that equals 1 if $ITAR_{ct}$ falls in the n^{th} quintile of its province. In equation (3), the value of *ITAR* is independent of the province, while

[34] The reason for using quintiles is that all provinces have at least 5 cities.

[35] Note that, within a province, a city's *Rank* and *ITAR* are correlated. However, they have different impacts on *YER*: A city might have a large value of *ITAR*, while *simultaneously* ranking low within the province. This occurs if many cities in a province have high values of *ITAR*. In other words, *Rank* and *ITAR* are correlated only within a province but not across provinces.

[36] Since the four municipalities are by definition cities, they always rank first. For all regressions in the empirical part, we have repeated them without including the four municipalities. All results remain almost identical. After all, despite their size they only constitute four cities in the data.

Rank must be measured against the province a city belongs to. This creates independent impacts of the two variables on *YER*.[37] The group ranked in the third quintile is taken as the reference group, and therefore $Rank_{ct}^{3}$ is omitted from the regression. Similar to Eq.(2), μ_c *and* μ_t denote city-fixed effects and year-fixed effects, respectively.

Since *ITAR* and *Rank* are correlated within a province, the regression is only used as a baseline to facilitate the subsequent analysis. As a reference, in addition to estimating Eq. (3), we also estimate a specification excluding *ITAR*, to assess how *Rank* alone influences *YER*. The results from both regressions are reported in Table 3 and illustrated in Figure 2. Column (a) of Table 3 and the corresponding Figure 2 reveal a clear monotonically increasing relationship between *YER* and *Rank*. This provides strong evidence that a city's *relative* interim performance within its province significantly affects the extent of its year-end patent surge: the more a city lags behind at the end of September, the more patent applications it will file relative to the first ten months. Column (b) of Table 3 adds *ITAR* to the regression. The coefficient on *ITAR* is negative and statistically significant, indicating that the extent to which a city is on track to meet its target also contributes to the year-end rush. Importantly, the inclusion of *ITAR* does not attenuate the positive and monotonic relationship between *Rank* and *YER*.

Ranking cities based on their *ITAR* has the advantage of enabling comparability across cities of different sizes. As shown in Table 1, patent filings vary greatly across provinces and cities. Measuring performance using a city's own growth rate—relative to its performance in the previous year—helps to eliminate this size variation. However, as noted earlier, this approach raises concerns about the correlation between *ITAR* and *Rank,* which may confound their respective effects on the year-end rush in regression (3). As an alternative, we define *Rank* based on the total number of patent applications filed in the first nine months of the year. This has the advantage of being uncorrelated with *ITAR.* A potential concern with this definition is that cities within a province may differ significantly in size. A large city may always have a much larger number of patent applications than a smaller city, regardless of how much effort the smaller city exerts. For instance, a city ranked 5th in a province might still have far fewer applications than the top-ranked city and may have little hope of catching up, even with an aggressive year-end push. Nevertheless, competition is likely to occur among cities of similar size. A city ranked 5th is not necessarily competing with the 1st-ranked city, but rather with those nearby in rank—say, those ranked 4th to 6th. Therefore, consistent with the logic when *Rank* is based on *ITAR,* we should still expect to observe a monotonically

[37] We will further look into this fact when we distinguish between the impacts of *ITAR* and *Rank* in Section 6.

increasing relationship between *YER* and *Rank* when the latter is based on the total number of applications filed by the end of September.

We then re-estimate Eq. (3) using this alternative measure of *Rank*. Column (c) of Table 3 and Figure 3 clearly show that *YER* increases monotonically with *Rank*, and the coefficients are statistically significant. This pattern holds not only for the total number of applications but also for each type of patent, as shown in Columns (d)–(f) of Table 3 and Panels (B)–(D) of Figure 3. Notably, across Columns (b) to (f), the coefficients on *ITAR* remain negative and statistically significant. This indicates that, at least before considering policy details, concern over meeting the target contributes to the year-end rush. Columns (a)–(c) of Table 3 and Figures 2 and 3 demonstrate that interim relative performance—captured by *Rank*—exerts an equally strong influence.

Since the number of cities in each province varies considerably, we have refrained from using pure rank (*PR*) as the primary measure of relative interim performance. However, even when using pure rank—rather than quintile rank—the results remain robust. Specifically, we rank cities by their *ITAR* within each province from 1st to 16th, use the 9th rank as the reference group, and re-estimate Eq. (3). As with the quintile-based rank, Table A3 and Figure A2 in Appendix 4 show a clearly increasing pattern of *YER* with a city's pure rank. Figure A3, analogous to Figure 3, presents results using the number of patents filed in the first nine months as the basis for calculating pure rank. These results are also robust and consistent across all types of patents. In fact, the findings in Table A3 and Figures A2 and A3 maybe even more illuminating than those in Table 3 and Figure 3: across the full range of pure ranks from 1 to 16, the coefficients for *PR* exhibit an almost uniformly monotonically increasing pattern.

As an additional robustness check on the influence of rank order, we examine the impact of rank changes on year-end filings. The hypothesis is that if a city's interim rank in year *t* is worse than its *year-end rank* in year *t-1*, it will face greater pressure to increase patent filings at the year-end. Importantly, this consideration is independent of the absolute value of *ITAR*; instead, it captures a change in a city's relative standing compared to the previous year. Column (a) of Table A4 in Appendix 5 shows that cities whose *ITAR* ranks have declined relative to their year-end ranks in *t-1* exhibit higher values of *YER* than those whose ranks remain unchanged. Conversely, cities whose *ITAR* ranks have improved compared to their year-end ranks in the previous year show lower values of *YER* than those with no rank change. Columns (b) through (d) demonstrate that this pattern also holds when examining each type of patent. Notably, *ITAR* remains negatively associated with *YER*, even in this analysis of rank changes.

To sum up, the influence of *Rank* on a city's year-end patenting behavior is highly robust. The monotonically increasing pattern to *YER* holds whether *Rank* is based on

ITAR or the total number of patent applications and whether interim performance is measured using pure rank or quintile-based rank. The results are also consistent when using rank changes instead of rank levels. Taken together, these findings provide compelling evidence that a city's relative interim performance plays a crucial role in shaping its year-end filing behavior. That said, *ITAR* itself also exerts a strong and consistent influence on *YER*. Regardless of whether *Rank* (or changes in *Rank*) is included in the regression, *ITAR* remains negatively associated with the year-end rush.

As a placebo test, we examine whether *ITAR* affects patent applications in months other than those at the year-end. Since the proportion of year-end applications is naturally negatively correlated with that of other months within the same year, we use the proportion of patent applications filed in the early months of the following year as the dependent variable in our placebo tests. If our baseline results reflect a genuine year-end effect, then *ITAR* and *Rank* from the current year should have no impact on filings in the subsequent year. As shown in Figures A4 and A5 in Appendix 6, the estimated coefficients on the *Rank* dummies—whether based on pure ranks or quintile ranks—are collectively insignificant when the outcome is the share of applications filed in the early months of the following year. These placebo results reinforce the validity of our main findings and suggest that the baseline pattern is unlikely to be driven by unobserved confounders or model misspecification.

6. Growth Target versus Rank in Explaining the Year-End Rush

6.1 Differential Impacts of ITAR versus Rank

The results in the baseline model have shown that both growth targets and career tournaments contribute to the year-end rush. In this section, we will argue that the underlying cause of the year-end rush is the latter, and the former only exacerbates it.

To support this claim, we exploit two institutional details in Section 3. First, the Chinese central government first suggested a national patent growth target in 2001 (at 14%), and provincial governments subsequently introduced their own targets, mostly around 2005–2006 (see Table A1 in Appendix 2). Since our analysis is conducted at the city level, the implementation of provincial targets around 2005 is the more relevant benchmark.[38] Accordingly, if the growth target policy drives the year-end rush, a city's *ITAR* should only begin to influence *YER* after 2005. In contrast, since the central government had already emphasized the importance of patents as early as the 1980s, if relative performance within a province reflects a career tournament, we would expect the influence of *Rank* on *YER* to be significant throughout the years covered by our data.

[38] Whenever we run a regression using 2005 as the threshold, we also run a corresponding regression using 2001 as the threshold. The results are almost the same.

Second, although both *ITAR* and *Rank* are derived from interim performance, they reflect different dimensions of a city's performance and incentives. *ITAR* is an absolute measure—it reflects a city's own performance relative to its past and is unrelated to the performance of other cities. In contrast, *Rank* is a relative measure—it captures a city's relative position within its province and therefore depends on the performance of other cities as well. Consequently, a city can have a high (or low) *ITAR* while ranking low (or high) within its province. Moreover, the two variables differ in how they shape incentives. The influence of *ITAR* is likely to exhibit a kinked pattern: once a city meets its growth target, the incentive to further increase patent filings diminishes. In other words, the *YER* should become insensitive to *ITAR* once the growth threshold has been met. *Rank*, on the other hand, reflects relative standing, and should continue to exert pressure regardless of a city's absolute performance—competition persists even among cities that have already met their targets. As shown in Table A1 in Appendix 2, provincial growth targets vary not only in their numerical values but also in how they are defined and implemented. However, most provinces' targets fall within the 10%–18% range. For our empirical analysis, we treat these targets as a threshold: if growth targets drive the year-end rush, then once a city surpasses the threshold, the pressure should subside. To address the possibility that local officials may prefer a comfortable margin above the target—given uncertainty in year-end outcomes—we use a higher benchmark of 20% growth rate. Specifically, if a city's patent applications in the first nine months exceed 1.2 times the total in the same period of the previous year, the city should no longer experience significant pressure to boost filings at year-end. In such cases, *YER* should be unresponsive to *ITAR*. Conversely, for cities with *ITAR* below 1.2, we expect *YER* to decline as *ITAR* increases. On the other hand, per tournament explanation, *YER* should remain monotonically increasing in *Rank*, regardless of whether the city has already exceeded the 1.2 threshold.

Before delving into the regression analysis, we first take a quick look at the data. Appendix 7 presents two visual illustrations of the roles played by growth targets and relative rank. First, Figure A6 shows cumulative distributions of *ITAR* for two time periods: 1986–2004 and 2006–2019. The figure reveals that 49.32% of cities in the earlier period, and 60% in the latter, had *ITAR* values exceeding the 1.2 threshold—indicating that a substantial portion of cities comfortably met their growth targets at the end of September. Moreover, the distribution for 2006–2019 slightly first-order stochastically dominates that for 1986–2004. This suggests a modest upward shift in *ITAR* after 2005, reflecting a general increase in interim growth rates in the post-policy period. Based on this observation, we estimate the monthly trend model described in Eq. (2) for two subsamples, based on whether a city's *ITAR* exceeds the 1.2 threshold.

The results are displayed in Figure 4. The figure clearly shows that the year-end rush is present in both subsamples—i.e., regardless of whether a city has already met its growth target. If growth targets were the sole driver of the year-end rush, we would expect cities with *ITAR* values above 1.2 to have little incentive to accelerate their patent filings at year-end. However, the data contradicts this: while the year-end rush appears slightly stronger after 2005, it was already prevalent in the period before the formal introduction of growth target policies.

The second difference between the influence of *ITAR* and *Rank* is the result of the timing of the growth target policy—before 2005 and after 2006. We estimate a polynomial function of *YER* with respect to *ITAR*, separately for observations below and above the 1.2 threshold, and for the pre-2005 and post-2005 periods. The results are presented in Figure A7 in Appendix 7. On the right-hand side of the threshold--when *ITAR* exceeds 1.2--*YER* still exhibits a negative association with *ITAR*, although the decline appears steeper on the left-hand side of the threshold. Importantly, the figure shows that a pronounced year-end rush existed even before 2005. This pattern suggests that while the growth target policy may have intensified the year-end surge in patent filings, the phenomenon was already present before the formal adoption of the policy—supporting the view that career concerns, rather than growth targets alone, are a fundamental driver of the year-end rush.

It is useful to discuss the findings of Sun et al. (2021) in more detail. Using national-level aggregate annual data, their study sets 2001—the year when the Chinese government first introduced a national patent growth target of 14%—as the treatment year in a difference-in-differences (DID) analysis. Their results indicate a clear increase in the year-end rush in patent filings after 2001, and they attribute the inefficiency of these filings (in terms of patent quality) to the implementation of the patent growth target policy. While this is a plausible and reasonable explanation, we believe it does not fully capture all the underlying causes of the year-end rush. First, similar year-end filing surges have been observed in other countries that do not impose top-down patent growth targets. For example, Park and Shin (2023) document a comparable pattern in South Korea, suggesting that such behavior may arise from broader bureaucratic or institutional incentives beyond formal target-setting. Second, although the DID approach in Sun et al. (2021) identifies an increase in the year-end rush after 2001, by its design it cannot rule out the presence of such behavior before 2001. In fact, Figure

2 in their paper also clearly shows a pronounced year-end surge before the introduction of the national growth target.[39]

We thus re-estimate the monthly trend model across three distinct periods: pre-2001, 2001-2005, and post-2005. As shown in Figure 5, the year-end rush remains evident throughout all three periods. This persistent pattern strongly indicates that the growth target policy cannot be the exclusive driver of the year-end rush.

6.2 The Effect of Rank on the Year-End Rush

We now turn to examine whether a tournament based on relative performance can accommodate the evidence that cannot be explained by the target fulfillment argument. Our identification strategy is to see whether there is any difference in the influence of *Rank*, first between subsamples whose *ITAR* is greater or smaller than the 1.2 threshold, and then between subsamples before and after 2005.

First, we regress *YER* on *Rank* dummies using two subsamples: one for cities with *ITAR* above 1.2 and another for those below this threshold. For each subsample, we recalculate the rank order of *ITAR* within each province.[40] As before, cities in the third quintile serve as the reference group. Figure 6 shows that, regardless of whether a city's *ITAR* exceeds 1.2, the lower its interim *Rank*, the greater its year-end rush. This indicates that even in the absence of pressure to meet the growth target, cities with lower interim performance still tend to file more intensively at year-end. These findings support the interpretation that the year-end surge is driven by relative performance competition, independent of the growth target. They also suggest that the negative coefficient on *ITAR* in Columns (b) and (c) of Table 4 may be attributable to its correlation with *Rank*.

Next, we examine whether the influence of *Rank* on the year-end rush differs between periods before and after the growth target policy. Since 2001 was when the national target was proposed and 2005 was for provincial targets, we estimate their relationship across three distinct periods: before 2000, between 2000 and 2005, and after 2005. As discussed in Section 3, while explicit patent growth targets were formally introduced at the national level in 2001 and adopted by most provincial governments only after 2005, the Chinese government had already begun emphasizing innovation—and patent performance in particular—well before 2000. Therefore, although *ITAR* should not have played a formal role before 2000, career-related incentives tied to

[39] To be fair, the purpose of Sun et al. (2021) might not be to show that a growth target policy *causes* a year-end rush, but that the year-end rush did increase significantly after the growth target policy was implemented in 2001, which resulted in great inefficiency.

[40] We adopt subsample analysis, rather than incorporating the cities into one regression, because *Rank* is incomparable between cities in the two groups.

relative performance may have influenced the year-end rush throughout the entire period. To test this hypothesis, we regress *YER* on *Rank* separately for the pre-2000, 2000–2005, and post-2005 subsamples.

Figure 7 shows that relative performance, as measured by *ITAR* ranking, has a monotonically increasing effect on the year-end rush in all three periods. The estimated coefficients on the *Rank* dummies display a clear upward trend as cities move from higher to lower ranks, even in the pre-2000 subsample. This provides further support for the argument that career concerns are a key driver of the year-end surge in patent filings. Moreover, the gap in year-end rush between top- and bottom-ranked cities widened significantly after 2005, suggesting that the introduction of explicit growth targets has intensified cross-city competition.

6.3 Growth Targets and Relative Performance in an Integrated Regression

To disentangle the role of the growth targets and tournament in terms of their impacts on the year-end rush, we estimate the following regression, with one using the subsamples for which the value of *ITAR* is greater than 1.2, and the other less than 1.2:

$$YER_{ct} = \alpha_0 + \alpha_1 ITAR_{ct} + \alpha_2 ITAR_{ct} \cdot Post2005 + \sum_{n=\{1,\cdots,N\}} \beta_n \cdot Rank_{ct}^n + \mu_c + \mu_t + \varepsilon_{ct}, \qquad (5)$$

where all variables are defined in the same way as in Eq. (4). *Rank* is recalculated for cities in the same province after splitting the samples. Again, cities in the 3rd quintile serve as the reference group.

Columns (a) and (b) of Table 5 present the estimation results of Eq. (5) for the subsample of cities with an *ITAR* greater than 1.2. Column (a) clearly shows that the year-end rush increases monotonically as a city's rank worsens. Column (b) confirms that this pattern persists even after including *ITAR* and its interaction term in the regression. Notably, the coefficients on *ITAR* and its interaction terms are statistically insignificant, although negative as expected. This suggests that once a city has met the growth target, *ITAR* no longer influences year-end behavior. Instead, a city's relative standing remains a key determinant in a way consistent with Propositions 1 and A1. Moreover, the results indicate that, after exceeding the threshold, *ITAR* has insignificant impacts on year-end rush behavior, even in the post-2005 period.

By contrast, columns (c) and (d) of Table 5 report the results for the subsample of cities with *ITAR* values below 1.2. The results in column (c) continue to show a monotonically increasing pattern in the coefficients of *Rank*. When *ITAR* and its interaction term are included, column (d) reveals that the coefficient on $ITAR$ is negative, as expected. More revealing, however, is that the interaction term $ITAR \times Post_{2005}$ is statistically insignificant, suggesting that the effect of $ITAR$ does not experience a discontinuous jump after 2005, a result that is consistent with the nature of its influence. Although the coefficients on the $Rank$ dummies become smaller and some lose statistical significance, the overall monotonic pattern remains. Taken together, the evidence shows that for cities that have already met the growth target, their year-end filing behavior is driven solely by their relative standing in the $ITAR$ ranking within their province. For those that have not yet met the target, both the level of $ITAR$ and their relative rank matter. These findings support our claim that tournament-style competition is the underlying cause of the year-end rush, and the growth target policy only exacerbates it.

To further support the fundamental influence of *Rank*, we focus on a subsample of cities whose values of *ITAR* are greater than 1.2 and rank in the lower two-thirds of cities within their respective provinces. If tournament-style competition—rather than growth target fulfillment—is the primary driver of the year-end rush, then these conditions lead to two testable predictions. First, since the growth target has already been met, the coefficient on *ITAR* should be insignificant. Second, because these cities rank relatively low, the coefficients on the *Rank* dummies should remain significantly and monotonically increasing. The results, reported in columns (e) and (f) of Table 5 and visualized in Figure 8, confirm both predictions. First, Table 5 shows that the coefficient on $ITAR$ is statistically insignificant. Second, both Table 5 and Figure 8 demonstrate that the coefficients of $Rank$ continue to follow a clear, monotonically increasing trend. These findings, again, support our claim that tournament incentives are the fundamental cause of the year-end rush.

7 The Role of the Patent Agency

There has been a missing link in our argument so far: patent applications are filed by inventors (i.e., firms, institutions, and individuals), *not* by the city officials themselves. While city leaders face political incentives tied to growth targets and relative performance, the inventors are not direct participants in the political tournament. For our proposed explanation to hold, we need to show that Chinese cities can provide incentives to the inventors to facilitate the local officials' political needs. How does a city align the incentives of the inventors with its political leader?

We hypothesize that this alignment of incentives is accomplished through patent agencies. Local governments—often informally, or as locally described, by "having a cup of tea" with inventors—encourage and subsidize patent filings for inventions that might otherwise have gone unfiled, either due to their low quality or premature stage of development. This pressure is operationalized by delegating the filing process to patent agencies, which serve as intermediaries between local officials and inventors. By doing so, the local governments essentially encourage filings by decreasing or even eliminating the cost of filing patents for the inventors. If this mechanism is at work, it yields two testable implications. First, the share of patent applications filed through agencies, relative to those filed directly by inventors, should increase significantly in November and December—precisely when year-end pressure peaks. Second, the quality of agency-filed patents should be systematically lower than that of non-agency-filed patents during these final two months of the year. More specifically, we expect the quality gap between agency and non-agency filings to be significantly negative in November and December, while remaining close to zero or statistically insignificant during the rest of the year.

To test the first implication, we estimate Eq. (2) using the monthly share of patent filings submitted via agencies as the dependent variable. Figure 9 shows that December consistently exhibits the highest proportion of agency-filed patents—a pattern observed across all types of patents.[41] To further explore the relationship between agency involvement and the year-end rush, we fit a polynomial function relating the extent of the year-end rush to the share of patents filed by agencies in January and December. In Figure 10, the horizontal axis measures the *YER* for each city year, while the vertical axis depicts the proportion of annual patent filings submitted via agencies in January and December, respectively. The figure reveals a clear positive relationship in December: cities with more intense year-end rushes tend to have a higher share of patents filed through agencies in that month. By contrast, no such relationship is observed for January. This provides strong evidence that patent agencies play an active role in facilitating the year-end surge in patent filings.

For the second implication, Figure 11 plots the quality differences between agency-filed and non-agency-filed patents across months. The figure shows that during the first ten months of the year, there is no statistically significant quality gap between the two groups. However, a significant negative difference emerges in November and December, indicating that patents filed through agencies are of substantially lower quality than those filed independently during these final two months. Taken together, Figures 9–11 provide compelling evidence in support of the hypothesis that patent agencies play a central role in enabling the city's push for patent filings at year-end.

[41] This is especially the case for design patents, as these are the types of patents that are easiest to manipulate.

For a side interest, Appendix 8 shows that the channel through which the cities drive the patent rush is by filing patents of marginal quality, rather than forwarding innovations that are planned for earlier next year. In fact, Figures A4 and A5 from the placebo test (Appendix 6) have already suggested that cities engage in year-end rushing by filing low-quality patents, rather than by merely advancing applications originally planned for the following year. This interpretation is supported by the null result that a city's current-year *Rank* has no significant effect on patent filings in the early months of the subsequent year—a pattern we would expect if cities were simply bringing forward next year's intended applications.

8 Conclusions

This paper proposes a theory to explain the pervasive year-end rush—or, more broadly, the fourth-quarter effect—commonly observed in organizational behavior. We argue that this regularity arises from tournament-style incentives driven by career concerns, particularly when interim performance is observable among contestants. Using patent application data from Chinese cities spanning 1985 to 2019, we provide empirical evidence that supports this theory. Chinese cities display a pronounced surge in patent filings toward the end of the year. Furthermore, the weaker a city's interim patent performance—measured relative to other cities within the same province—the more pronounced its year-end filing activity becomes, resulting in a clear, monotonically increasing relationship between relative interim performance and the intensity of the year-end rush. Chinese cities offer an ideal empirical setting for this analysis, given their central role in national economic development and the well-documented tournament-based nature of bureaucratic promotions in China.

Our results have two important implications. First, sometimes the distortions of a policy are not caused by the policy per se, but arise simply because the policy's goal itself creates a tournament between those involved, which results in "mild government failure," to borrow the words from Wei et al. (2023). As long as there is competition, there emerge incentives that might conflict with a policy's original goal. Second, the theory proposed in the paper points out the unique role of the end period in a multi-period competition or evaluation, and might shed light on many other types of year-end anomalies recorded in the literature.

Tables

Table 1: Number of cities in each province

Province	Number of cities	Avg. No. of Patents of a city		Province	Number of cities	Avg. No. of Patents of a city	
		1990	2019			1990	2019
Shanghai	1	1380	175453	Jiangsu	13	171	44446
Beijing	1	3370	228049	Heilongjiang	13	74	2658
Tianjin	1	851	86086	Guangxi	14	31	2755
Chongqing	1	410	62689	Hunan	14	137	7013
Ningxia	5	17	1788	Gansu	14	14	1632
Xizang	5	-	385	Liaoning	14	203	4802
Qinghai	8	12	613	Yunnan	16	20	2016
Jilin	9	90	3240	Anhui	16	17	9468
Fujian	9	45	16378	Shandong	16	137	15626
Guizhou	9	14	4376	Hainan	17	2	500
Shaanxi	10	82	7914	Hubei	17	52	8015
Shanxi	11	42	2714	Henan	18	42	7203
Jiangxi	11	39	7357	Xinjiang	19	7	736
Hebei	11	112	8733	Sichuan	21	64	5772
Zhejiang	11	171	37635	Guangdong	21	81	36377
Inner Mongolia	12	19	1638	Total	358	63	11034

Notes: There are 358 cities from 27 provinces and 4 municipalities. The average number of patents is calculated by dividing the total number of patent applications within a province by the number of cities in that province. This metric is reported for the years 1990 and 2019.

Table 2: Summary statistics and description of the variables

Variables	Mean	Std. Dev.	Min	Max	Obs.	Definitions
(A) City-year-month level variables						
$Patent_m$	0.099	0.085	0.001	1	122,475	The proportion of patent applications filed in month m of the year
$Month_m$	6.558	3.441	1	12	122,475	Dummy variable, which equals 1 for the m-th month of a year
Agency	0.646	0.296	0	1	122,475	The proportion of patent applications filed through patent agencies
Citation3	0.667	0.579	0.011	18	34,855	The average number of forward patent citations within three years
Citation5	1.037	0.917	0.006	25	35,074	The average number of forward patent citations within five years
(B) City-year level variables						
YER	0.218	0.081	0.043	0.554	9,267	Ratio of patent applications in the last 2 months
ITAR	1.296	0.524	0.442	4.333	9,267	Ratio of patent applications in the first 9 months of year *t* to those in the first nine months of year *t*-1
Rank	7.356	4.364	1	16	9,267	Dummy variable, indicating the rank order of *ITAR* among all cities in the same province
Below	0.507	0.500	0	1	9,267	Dummy variable, 1 for cities whose *ITAR* exceeds 1.2, and 0 otherwise
Post2005	0.534	0.499	0	1	9,267	Dummy variable, 1 for years in and after 2005, and 0 otherwise

Notes: All variables, except for citations, are calculated based on all patents, regardless of patent type, for the period from 1985 to 2019. Citation variables are based on invention patents, covering the period from 1985 to 2016. In order to calculate three-year citations, the sample is limited to patents filed before 2013, and for five-year citations, the sample is limited to those filed before 2011. City-year-month observations with zero citations for the citation variables are excluded.

Table 3: Rank effects on year-end rush

	Baseline		Robustness Checks			
Dependent Var.: *YER*	(a) All patents	(b) All patents	(c) All patents	(d) Invention patents	(e) Utility model	(f) Design patents
ITAR		-0.018***	-0.025***	-0.015***	-0.013***	-0.006***
		(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
$Quintile1$	-0.024***	-0.013***	-0.026***	-0.043***	-0.030***	-0.063***
	(0.003)	(0.003)	(0.004)	(0.006)	(0.004)	(0.007)
$Quintile2$	-0.006**	-0.003	-0.009***	-0.024***	-0.015***	-0.034***
	(0.003)	(0.003)	(0.003)	(0.005)	(0.003)	(0.006)
$Quintile4$	0.008***	0.005*	0.022***	0.026***	0.017***	0.038***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.006)
$Quintile5$	0.023***	0.016***	0.052***	0.069***	0.049***	0.111***
	(0.003)	(0.003)	(0.003)	(0.005)	(0.004)	(0.007)
Constant	0.218***	0.241***	0.248***	0.247***	0.231***	0.226***
	(0.002)	(0.003)	(0.003)	(0.004)	(0.003)	(0.005)
City & Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,267	9,267	9,267	9,165	9,267	8,462
R-squared	0.238	0.244	0.265	0.197	0.215	0.160

Notes: This table presents the estimated results of Eq. (3). In panels (a) and (b), the quantile rank is determined by the rank of the interim target achievement rate. In panels (c) through (f), the quantile rank is based on the rank of the interim number of patent applications. Robust standard errors are shown in parentheses; ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. $Quintile3$ is taken as the baseline group and is omitted from the regression.

Table 4: Effects of target setting on the year-end patent rush

Dependent Variable: *YER*	(a)	(b)	(c)
$Below$	0.009***	0.070***	0.068***
	(0.002)	(0.008)	(0.011)
$ITAR$	-0.026***	-0.012***	-0.012***
	(0.002)	(0.003)	(0.003)
$Below \times ITAR$		-0.060***	-0.059***
		(0.007)	(0.010)
$Below \times Post2005$		0.005	0.008
		(0.004)	(0.015)
$ITAR \times Post2005$		-0.012***	-0.011***
		(0.004)	(0.004)
$Below \times ITAR \times Post2005$			-0.003
			(0.014)
City & Year FEs	Yes	Yes	Yes
Observations	9,267	9,267	9,267
R-squared	0.239	0.247	0.247

Notes: This table presents the estimated results of Eq. (4). Robust standard errors are shown in the parentheses; ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

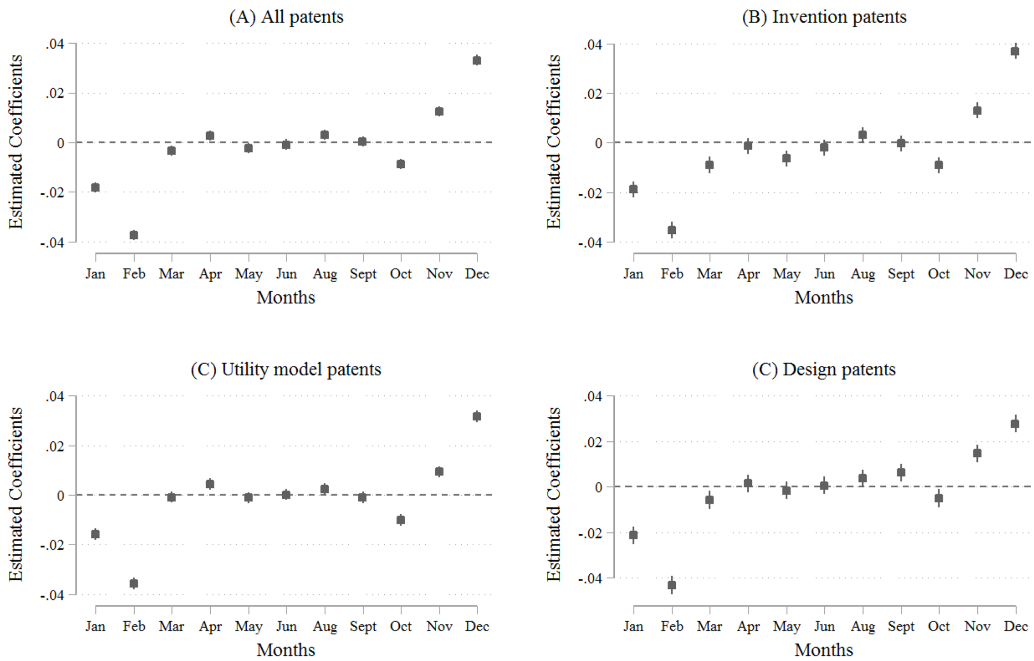
Table 5: The dominant role of rank effects in explaining the year-end rush

Dep. Var.: YER	Above target ($ITAR \geq 1.2$)		Below Target ($ITAR < 1.2$)		Above target & Ranked Behind	
	(a)	(b)	(c)	(d)	(e)	(f)
$ITAR$		-0.002		-0.058***		-0.008
		(0.004)		(0.013)		(0.006)
$ITAR \times Post2005$		-0.004		-0.005		-0.002
		(0.004)		(0.013)		(0.010)
$Quintile1$	-0.016***	-0.013***	-0.010***	-0.000	-0.008	-0.007
	(0.003)	(0.004)	(0.003)	(0.004)	(0.007)	(0.007)
$Quintile2$	-0.007**	-0.006*	-0.004	0.001	-0.002	-0.002
	(0.004)	(0.004)	(0.003)	(0.004)	(0.006)	(0.006)
$Quintile4$	0.004	0.004	0.008**	0.002	0.013**	0.012**
	(0.004)	(0.004)	(0.003)	(0.004)	(0.006)	(0.006)
$Quintile5$	0.011***	0.010**	0.022***	0.009**	0.019***	0.018***
	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)
Constant	0.212***	0.219***	0.227***	0.284***	0.208***	0.220***
	(0.002)	(0.005)	(0.002)	(0.010)	(0.004)	(0.008)
City & Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,565	4,565	4,686	4,686	3,382	3,382
R-squared	0.239	0.239	0.302	0.307	0.293	0.293

Notes: ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. $Quintile3$ is taken as the baseline group and is omitted from the regression.

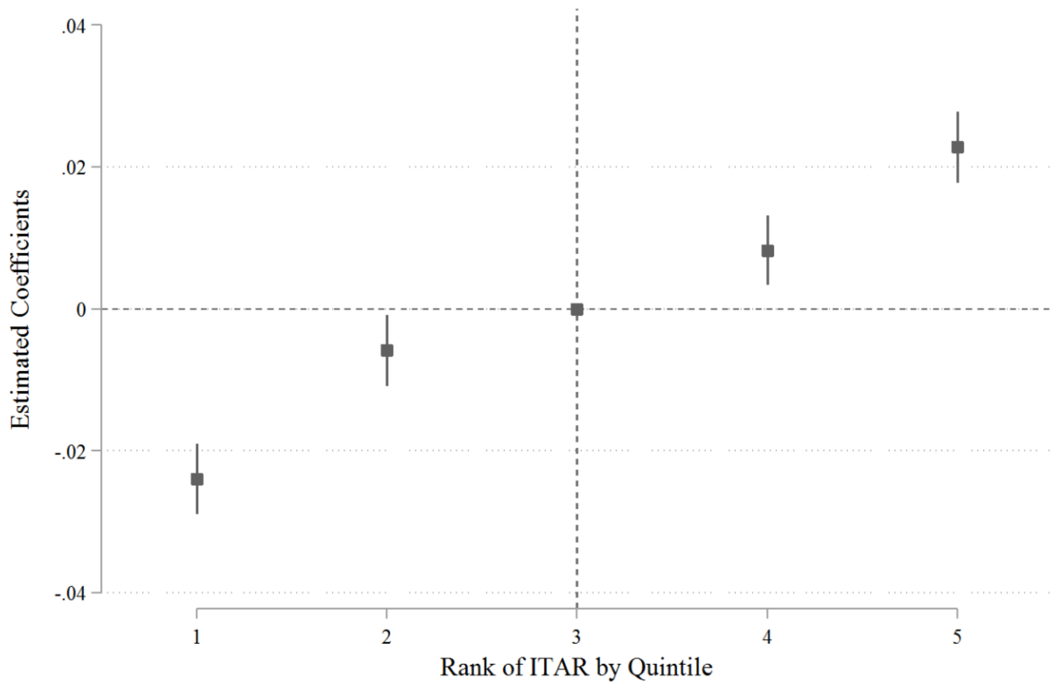
Figures

Figure 1: Year-end rush in patent applications



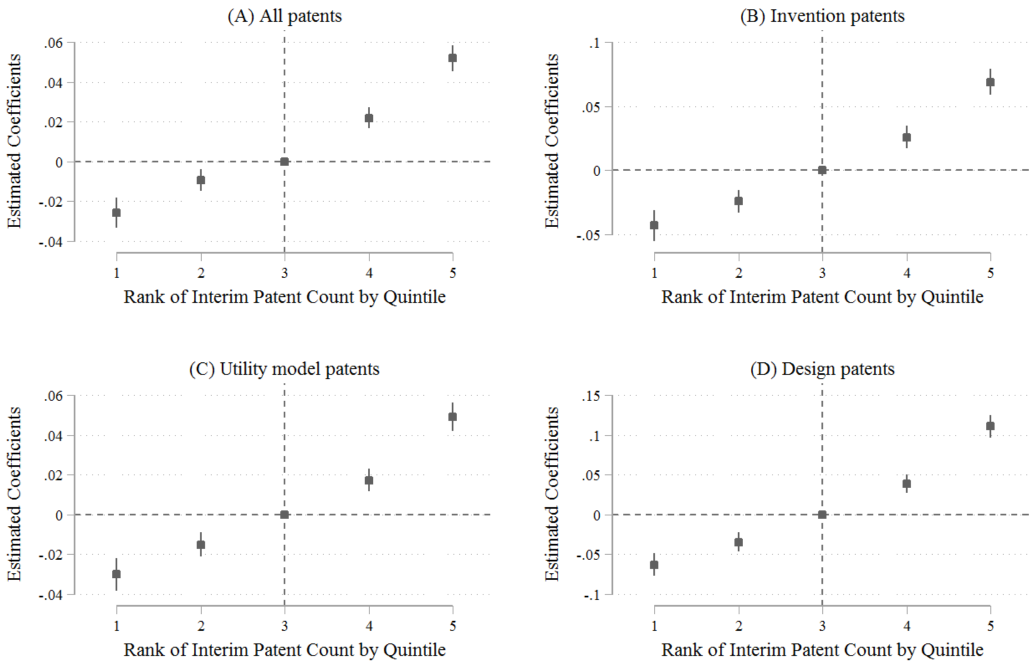
Notes: This figure depicts the estimated results of Eq. (2). Panel (A) displays the monthly trend of all patent applications, while panels (B) through (D) illustrate the trends for invention, utility model, and design patents, respectively.

Figure 2: Rank effects on the year-end rush in patent applications



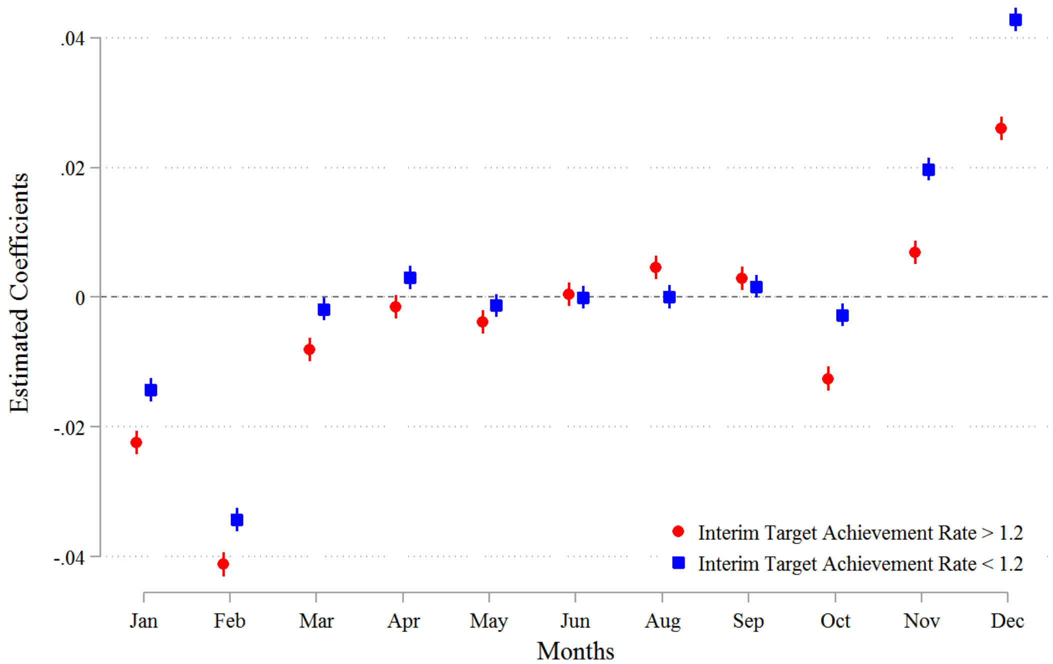
Notes: This figure illustrates the estimated coefficients of the quintile rank dummies in Eq. (3). The ranking is based on the interim target achievement rate (ITAR), with cities in the third quintile within their provinces serving as the reference group.

Figure 3: Rank order based on total number of patents filed in the first 9 months



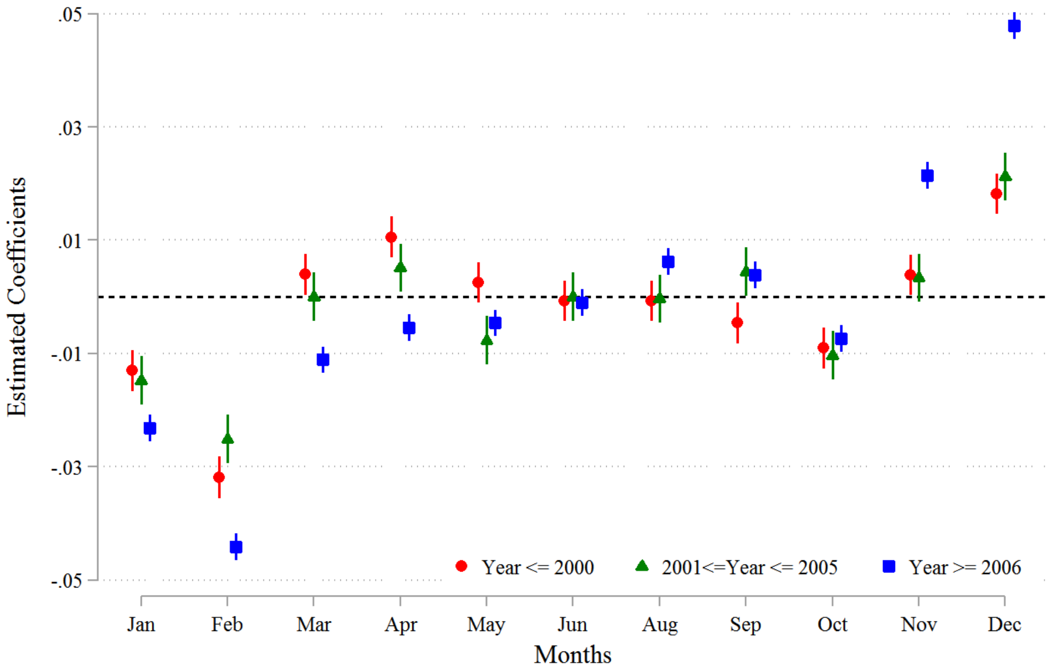
Notes: This figure illustrates the estimated coefficients of the quintile rank dummies in Eq. (3), when rank is based on the number of patents filed in the first nine months. Cities ranked in the third quintile within their provinces are used as the reference group.

Figure 4: Monthly trend for cities exceeding versus not exceeding targets



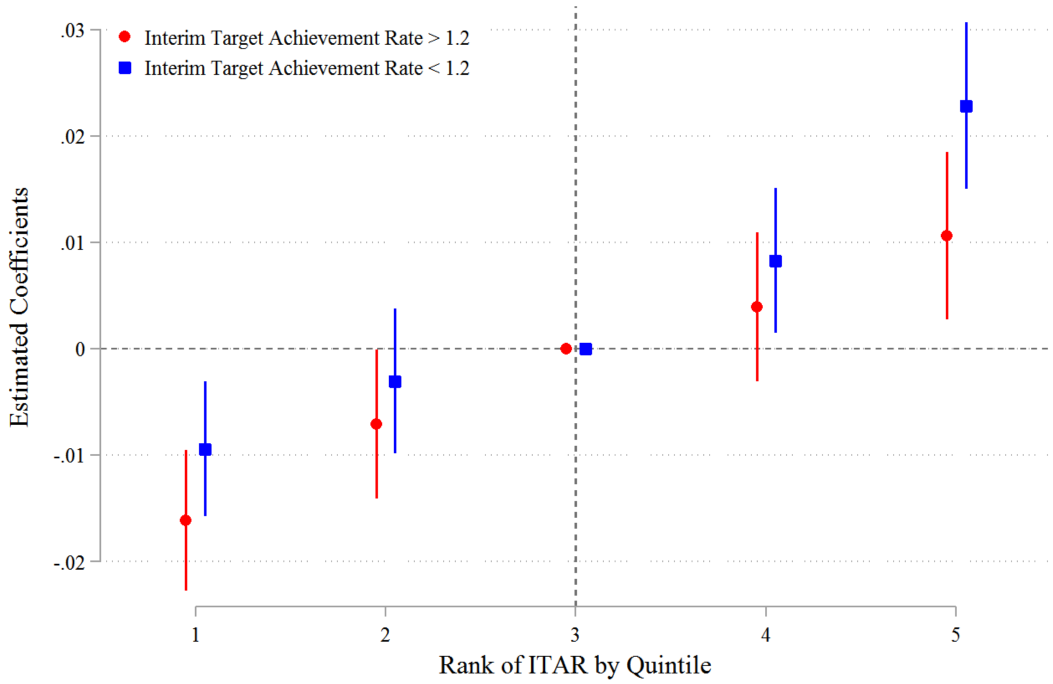
Notes: This figure depicts the estimated results of Eq. (2), displaying the monthly trend of all types of patent applications for the two subsamples of cities with an interim target achievement rate either below or above 1.2, respectively.

Figure 5: Monthly trend by subsample periods



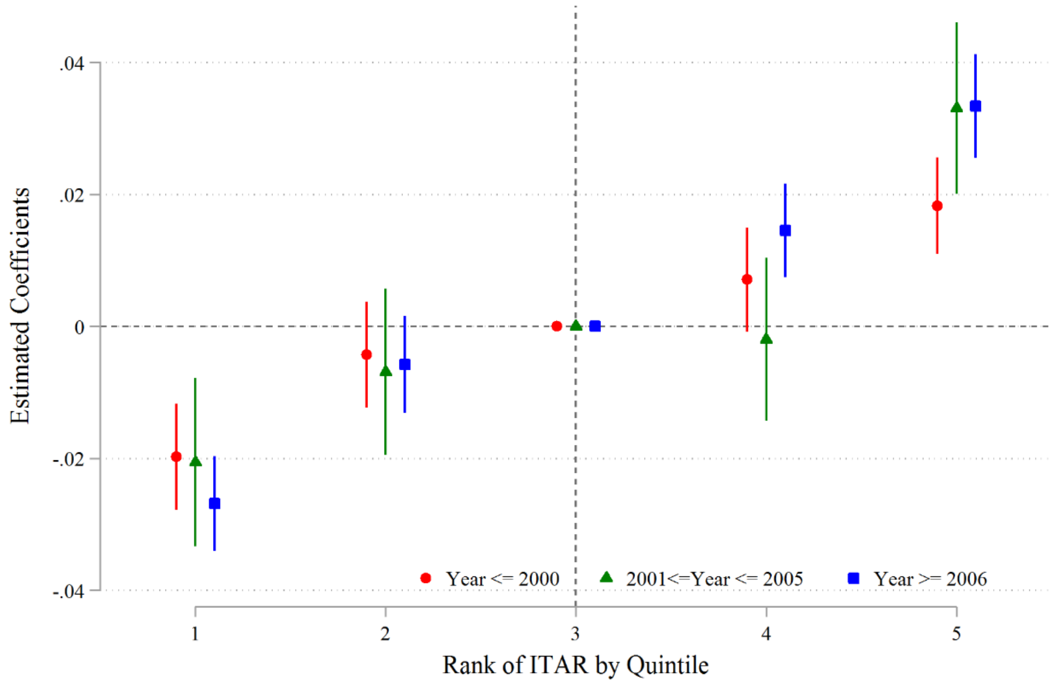
Notes: This figure depicts the estimated results of Eq. (2), displaying the monthly trend of all patent applications across three subsample periods: 1986-2000, 2001-2005, and 2006-2019.

Figure 6: Rank effects for cities exceeding versus not exceeding growth targets



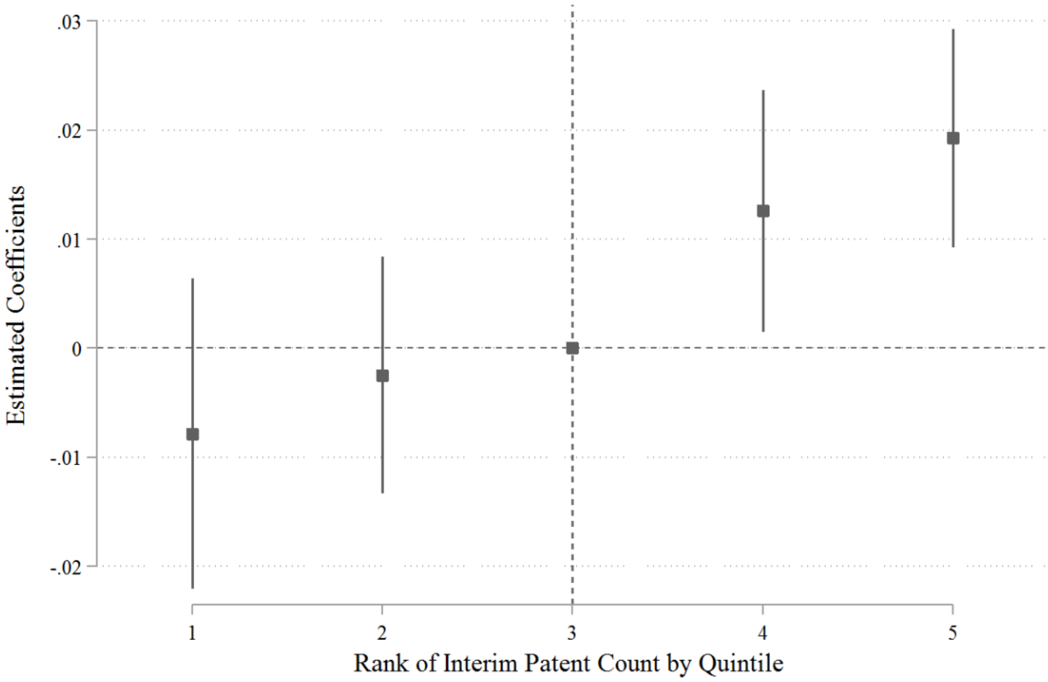
Notes: This figure illustrates the estimated coefficients of the quintile rank dummies from Eq. (3) for subsamples of cities with an interim target achievement rate (ITAR) either below or above 1.2, respectively. The ranking is calculated based on the value of ITAR within each subsample, with cities in the third quintile within their provinces serving as the reference group.

Figure 7: Rank effects before and after the growth target policy



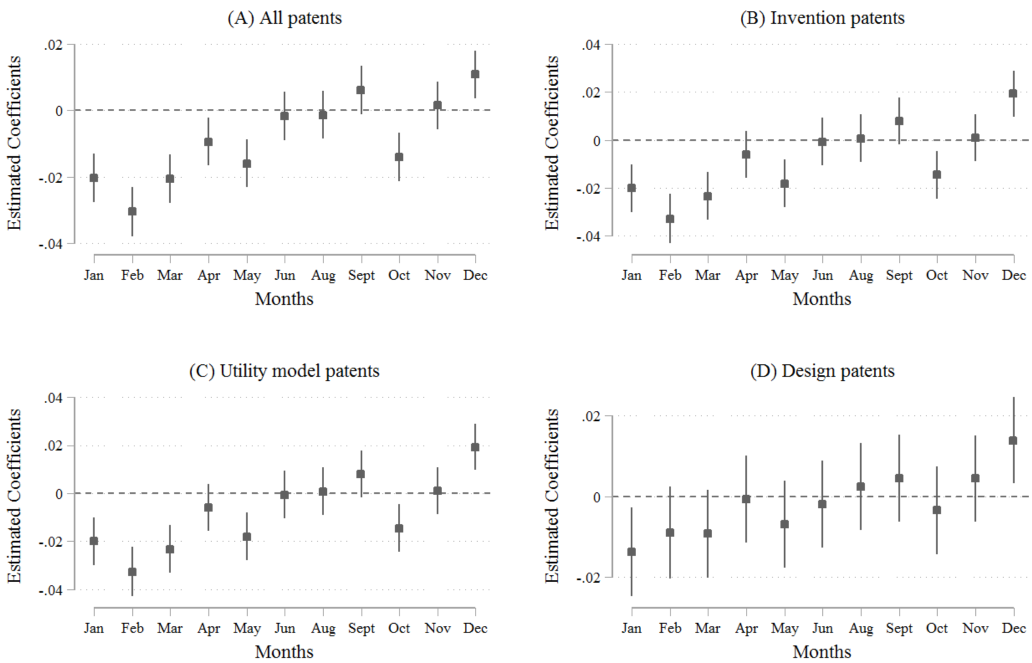
Notes: This figure illustrates the estimated coefficients of the quintile rank dummies from Eq. (3), for subsample periods. The ranking is calculated based on *ITAR*, with cities in the third quintile within their provinces serving as the reference group.

Figure 8: The subsample of cities with a high *ITAR* but rank low



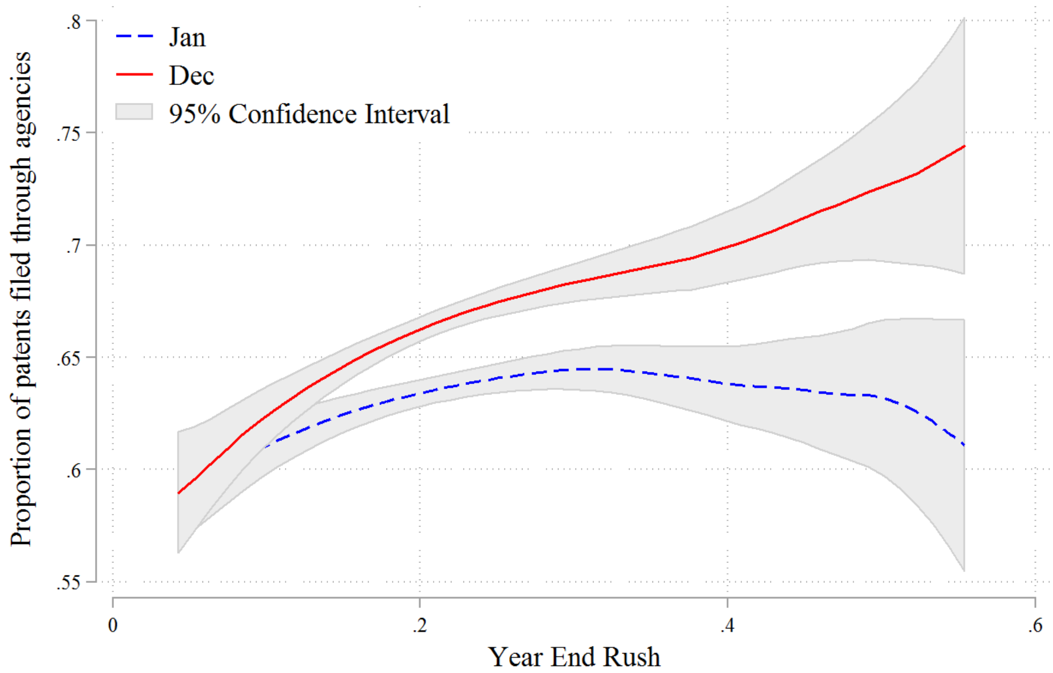
Notes: This figure illustrates the estimated coefficients of the quintile rank dummies from Eq. (3) for a subsample of cities with an *ITAR* greater than 1.2 but simultaneously ranked in the bottom two-thirds of their respective provinces. The ranking is calculated based on the interim patent count, with cities in the third quintile within their provinces serving as the reference group.

Figure 9: Proportion of patents filed through agencies



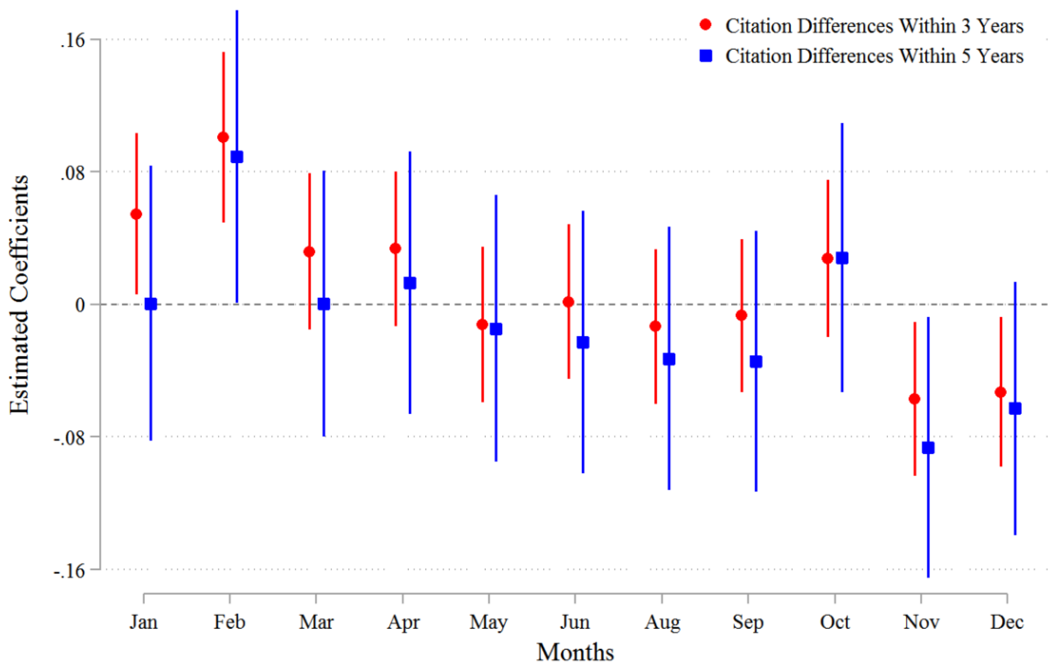
Notes: This figure presents the estimated coefficients from Eq. (2), using the proportion of patents filed by patent agencies as the dependent variable. Panel (A) displays the monthly trend for all types of patent applications, while panels (B) through (D) illustrate the trends for invention, utility model, and design patents, respectively.

Figure 10: Year-end rush and patents filed through agencies



Notes: This figure illustrates an increasing relationship between the year-end rush and the proportion of patents filed by agencies in December, while showing a flat trend for those filed in January. Local polynomial smooth plots with 95% confidence intervals are included.

Figure 11: Citation difference (Agency versus Non-Agency)



Notes: This figure depicts the estimated results of Eq. (2), using the difference in the average number of forward patent citations between patents filed by agencies and those filed by non-agencies. Citations are counted within 3 years and 5 years, respectively.

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Appendix 1: Extension of Proposition 1

This appendix extends Proposition 1 to the *n*-contestant case.

Assumption 1':

(1) $V' > 0$, $V'' < 0$, and $V''' > 0$.

(2) Let $P^i(Y_1, \dots, Y_N)$ denote the winning probability of player i, with

$$\sum_i P^i(Y_1, \dots, Y_N) = 1.$$

Then for any $i, j \in \{1, \dots, N\}$,

(i) Symmetry: $P^i\left(Y_1, \dots Y_i \dots Y_j \dots Y_N\right) = P^j\left(Y_1, \dots Y_j \dots Y_i \dots Y_N\right)$.

(ii) $\frac{\partial P^i(Y_1, \dots, Y_N)}{\partial Y_i} = P_i^i > 0$ and $\frac{\partial P^i(Y_1, \dots, Y_N)}{\partial Y_j} = P_j^i < 0$.

(iii) $P_{ii}^i < 0$.

(iv) $P_{ij}^i < 0$ if $Y_i > Y_j$; $P_{ij}^i > 0$ if $Y_i < Y_j$.

The symmetry assumption (i) in (2) implies that the contest success function is symmetric and depends only on performance, regardless of the player's identity. Assumption (ii) in (2) states that the winning probability increases with the contestant's own performance and decreases with the opponent's performance. Assumption (iii) of (2) indicates that the marginal winning probability decreases as the contestant's own performance improves. Assumption (iv) of (2) implies that player i's marginal probability of winning decreases with respect to player j's effort, when player i is ahead of j; and increases with respect to j's effort, when player i is behind j.

Proposition A1 *(The Catching-Up Effect) If all players put in effort such that the interim performance increases, i.e.,* $W_1 > W_2 > \cdots > W_N$, *then the second period effort level is monotonically reversed, i.e.,* $Q_1^2 < Q_2^2 < \cdots < Q_N^2$.

Proof: First, we show that, for any $i, j \in \{1, \dots, N\}$, $W_i > W_j$ implies that $Q_i^2 < Q_j^2$. The first-order conditions for Q_i^2 and Q_j^2 are:

$$V'(Q_i^2) - \mathrm{c} + \frac{\partial P^i(Y_1, \dots, Y_N)}{\partial Q_i^2} M = 0, \qquad V'\left(Q_j^2\right) - \mathrm{c} + \frac{\partial P^j(Y_1, \dots, Y_N)}{\partial Q_j^2} M = 0$$

Suppose that $W_i > W_j$ implies that $Q_i^2 \geq Q_j^2$. Then it further implies that $V'(Q_i^2) \leq V'\left(Q_j^2\right)$, and

$W_i + Q_i^2 = Y_i > Y_j = W_j + Q_j^2$ such that

$$\frac{\partial P^i\left(Y_1, \dots Y_i \dots Y_j \dots Y_N\right)}{\partial Y_i} < \frac{\partial P^i\left(Y_1, \dots Y_j \dots Y_j \dots Y_N\right)}{\partial Y_i} = \frac{\partial P^j\left(Y_1, \dots Y_j \dots Y_j \dots Y_N\right)}{\partial Y_j} < \frac{\partial P^j\left(Y_1, \dots Y_i \dots Y_j \dots Y_N\right)}{\partial Y_j}.$$

The first inequality comes from $P_{ii}^i < 0$, and the second inequality comes from $P_{ij}^j > 0$, when $Y_i > Y_j$. The equality comes from the symmetry of CSF. However, this will then lead to a contradiction, because in the second stage, $\frac{\partial Y_i}{\partial Q_i^2} = \frac{\partial Y_j}{\partial Q_j^2} = 1$ and $\frac{\partial Y_j}{\partial Q_i^2}$=0 for any $i \neq j$, so that

$$0 = V'(Q_i^2) - c + \frac{\partial P^i(Y_1, \ldots Y_i \ldots Y_j \ldots Y_N)}{\partial Y_i} \frac{\partial Y_i}{\partial Q_i^2} < V'\left(Q_j^2\right) - c + \frac{\partial P^j(Y_1, \ldots Y_i \ldots Y_j \ldots Y_N)}{\partial Y_j} \frac{\partial Y_j}{\partial Q_j^2} = 0$$

Therefore, for any *i, j,* $W_i > W_j$ implies that $Q_i^2 < Q_j^2$.

Since for any i, j, $W_i > W_j$ implies that $Q_1^2 < Q_j^2$, we know that $W_1 > W_2 > \cdots > W_N$ implies that the second period effort levels will have a monotonically reversed order, *i.e.,* $Q_1^2 < Q_2^2 < \cdots < Q_N^2$.

In the proof, we have used the fact that although $W_i > W_j$ implies that $Q_i^2 < Q_j^2$, Q_j^2 would not be so large as compared to Q_i^2 so that it results in a reversal of performance, i.e., $Y_i < Y_j$. Similar to the 2-contestant case, we show that this continues to hold in the *n*-contestant case. To be specific, suppose it does not and that we have $Y_i < Y_j$. This is because $V'' < 0$ and $Q_i^2 < Q_j^2$ implies that $V'(Q_i^2) > V'\left(Q_j^2\right)$. Again, $Y_i < Y_j$ further implies

$$\frac{\partial P^i(Y_1, \ldots Y_i \ldots Y_j \ldots Y_N)}{\partial Y_i} > \frac{\partial P^i(Y_1, \ldots Y_i \ldots Y_i \ldots Y_N)}{\partial Y_i} = \frac{\partial P^j(Y_1, \ldots Y_i \ldots Y_i \ldots Y_N)}{\partial Y_j} > \frac{\partial P^j(Y_1, \ldots Y_i \ldots Y_j \ldots Y_N)}{\partial Y_j}.$$

The first inequality comes from $P_{ij}^i > 0$ when $Y_i < Y_j$, and the second inequality comes from $P_{jj}^j < 0$. The equality comes from the symmetry of the CSF. Similarly, we derive the contradiction, because in the second stage, $\frac{\partial Y_i}{\partial Q_i^2} = \frac{\partial Y_j}{\partial Q_j^2} = 1$ and $\frac{\partial Y_j}{\partial Q_i^2}$=0 for any $i \neq j$, so that we have

$$0 = V'(Q_i^2) - c + \frac{\partial P^i(Y_1, \ldots Y_i \ldots Y_j \ldots Y_N)}{\partial Y_i} \frac{\partial Y_i}{\partial Q_i^2} > V'\left(Q_j^2\right) - c + \frac{\partial P^j(Y_1, \ldots Y_i \ldots Y_j \ldots Y_N)}{\partial Y_j} \frac{\partial Y_j}{\partial Q_j^2} = 0.$$

This is a contradiction. QED

Appendix 2: Timetable and Content of Chinese Patent Policies

In this appendix, we present the targets for both the overall and invention patent applications in each province, which were obtained from the original documents that initially specified these targets. There are two batches of specified targets: the first batch was established around 2005, coinciding with the implementation of the 11th Five-Year Plan. Most provinces specified targets in this batch, except for four provinces—Anhui, Heilongjiang, Jilin, and Liaoning—which first specified their targets in 2011 in the 12th Five-Year Plan. In some provinces, the targets are directly outlined in the Five-Year Plan, while others may be found in documents guided by the Five-Year Plan. Similarly, the targets for invention patents are specifically specified at the same time or later, as the government recognized that invention patents are the most valuable type of patents.

In terms of targets, some provinces explicitly specified the growth rate of patent applications, while others presented their targets in different ways. To the best of our knowledge, we have converted these targets into the annual growth rate to make them comparable, where this is feasible. Columns (1) and (2) document the province and its converted target from Column (5). Column (5) extracts the original target specifications from the documents in Column (4). Column (3) lists the year in which the documents were released. Table A1 is for all patents, and Table A2 is for invention patents.

Table A1: Target of number of overall patent applications in each province

Provinces	**Target**	**Year**	**Documents**	**Target in the Documents**
(1)	**(2)**	**(3)**	**(4)**	**(5)**
Guangdong	16.72%	2004	Decisions on accelerating the construction of a strong province in Science and Technology in Guangdong https://code.fabao365.com/law_335612_1.html	The annual number of patent applications per 10,000 people exceeds 9.8.
Jiangsu	17.2%	2006	Outline of the 11th Five-Year Plan for Scientific and Technology Development in Jiangsu https://www.jiangsu.gov.cn/art/2007/10/24/art_47069_2685292.html	Number of patent approvals exceeds 30,000 per year.
Sichuan	12%	2006	Outline of the 11th Five-Year Plan for Intellectual Property Development in Sichuan https://202.61.89.171:8443/proxy/zwgk/zdgk/ghjh/201502/t20150206_15137.html	12%
Guangxi	10%	2006	The Protection of Intellectual Property in Guangxi http://www.gxipo.net/gx/zs/ndgzbg/20150209/27704.html	10%
Zhejiang	10%	2006	Plan of the 11th Five-Year Plan for Patent Development in Zhejiang https://kjt.zj.gov.cn/art/2022/7/20/art_1229663286_59003705.html	10%
Hainan	15%	2006	Outline of the 11th Five-Year Plan for Scientific and Technology Development in Hainan https://www.hainan.gov.cn/hainan/szfwj/200606/859eddfa25b142f98decaaa848d4a37c.shtml	15%
Shanxi	15%	2006	Outline of the 11th Five-Year Plan for Intellectual Property Development in Shanxi	15%

			https://www.pthls.cn/law/6afee1b0119c4ae.html	
Inner Mongolia	20%	2006	Plan of the 11th Five-Year Plan for Patent Development in Inner Mongolia https://www.docin.com/p-22082160.html	Growth rate of patent applications reaches up to the average rate nationwide
Xinjiang	18%	2004	Opinions on the Intellectual Property Strategy Promotion Project in Xinjiang https://www.maxlaw.cn/t-bzzscqls1-com/artview/918925704823	18%
Jiangxi	10%	2006	Outline of the Medium- and Long-Term Plan for Scientific and Technology Development in Jiangxi (2006-2020) http://kjc.ncpu.edu.cn/guanlizhidu/shangjiwenjian/html.php?c-84.html	10%
Henan	17.63%	2003	Opinions on the Patent Strategy Promotion Project in Henan https://ipr.cupl.edu.cn/info/1323/5472.htm	Number of patent applications exceeds 10,000 per year
Fujian	12%	2006	Decision on Enhancing Innovation in the West Coast Economic Zone of the Strait http://www.xianyou.gov.cn/xkjj/xxgk/kjgl/201003/t20100317_1116175.htm	12%
Guizhou	15%	2006	Outline of the Medium- and Long-Term Plan for Scientific and Technology Development in Guizhou (2006-2020) https://www.guizhou.gov.cn/zwgk/zfgb/gzszfgb/200608/t20060831_70515607.html	15%
Yunnan	10%	2007	Outline of the 11th Five-Year Plan for Intellectual Property Development in Yunnan https://www.yn.gov.cn/zwgk/zfxxgk/dzjhbg/201903/t20190301_179286.html	10%
Anhui	20%	2011	Outline of the 12th Five-Year Plan for Patent Development in Anhui https://kjt.ah.gov.cn/public/21671/110126881.html	20%
Shandong	15%	2005	Outline of the Intellectual Property Strategy in Shandong (2005-2010) http://www.nipso.cn/onewsn.asp?id=14206	Growth rate of patent applications exceeds the average rate nationwide
Shanxi	7.58%	2006	Outline of the 11th Five-Year Plan for Economic and Social Development in Shanxi (2006-2010) https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfwj/202205/t20220513_5975725.shtml	Number of patent applications reaches up to 8.5 per 100,000 people
Hunan	15%	2006	Outline of the 11th Five-Year Plan for Intellectual Property Development in Hunan https://www.hunan.gov.cn/hnszf/xxgk/fzgh/201212/t20121210_4902879.html	15%
Hebei	12%	2006	Outline of the 11th Five-Year Plan for Science and Technology Development in Hebei https://china.findlaw.cn/fagui/p_1/89728.html	12%
Qinghai	15%	2006	Outline of the 11th Five-Year Plan for Science and Technology Development in Qinghai https://wenku.baidu.com/view/ea48ffd9935f804d2b160b4e767f5acfa0c7832d.html?_wkts_=1726475749355	15%
Ningxia	15%	2006	Outline of the 11th Five-Year Plan for Science and Technology Development in Ningxia https://kjkf.nxtc.edu.cn/info/1107/2790.htm	15%
Hubei	15%	2006	Outline of the 11th Five-Year Plan for the Intellectual Property Development in Hubei https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fzscqj.hubei.gov.cn	15%
Gansu	20%	2006	Outline of the 11th Five-Year Plan for the Science and Technology Development in Gansu https://wenku.baidu.com/view/fe58e9eecd1755270722192e453610661fd95ac3.html?_wkts_=1726476110597	20%

Heilongjiang	20%	2011	Outline of the Intellectual Property Development in Heilongjiang (2011-2020) https://www.hlj.gov.cn/hlj/c108166/201111/c00_30643858.shtml	20%
Jilin	18.15%	2011	Outline of the 12th Five-Year Plan for Science and Technology Development in Jilin http://kjt.jl.gov.cn/xxgk/lslm/ghjh/201604/t20160420_2200131.html	Number of patent approvals exceeds 10,000 by 2015
Liaoning	10%	2010	Plan for the Intellectual Property Strategy in Liaoning (2010-2012) https://www.ln.gov.cn/web/zwgkx/zfwj/szfbgtwj/zfwj2010/BB14717715F143D6B638B6B85694F54A/index.shtml	10%
Tibet	N/A	N/A	N/A	N/A

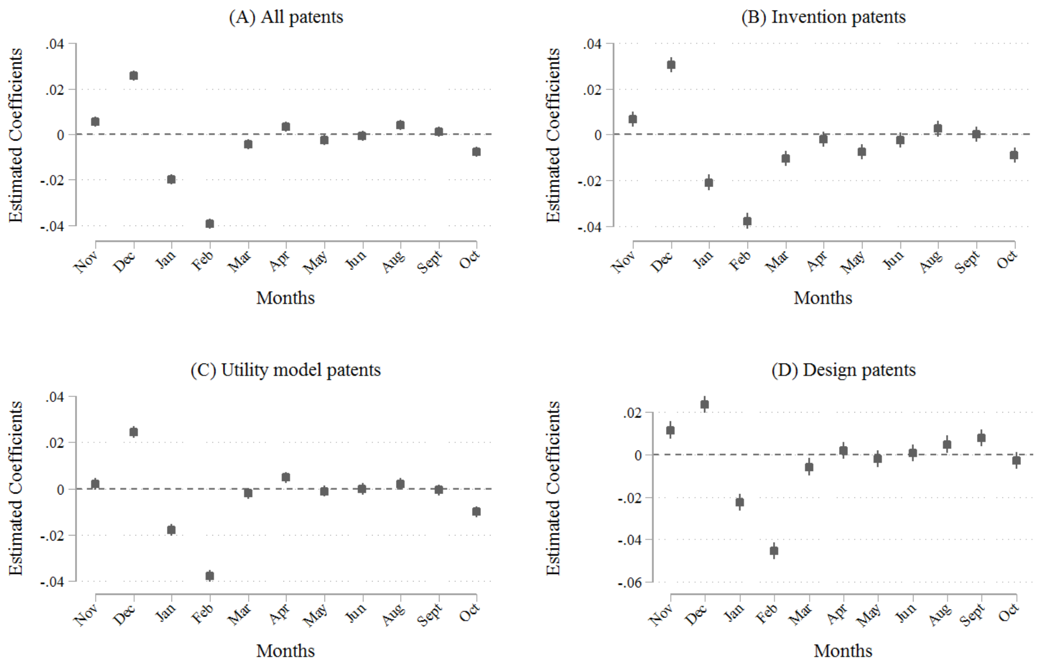
Table A2: Target number of invention patent applications in each province

Provinces	**Target**	**Year**	**Documents**	**Target in the Documents**
(1)	**(2)**	**(3)**	**(4)**	**(5)**
Guangdong	15%	2007	Plan for Intellectual Property Strategy in Guangdong https://amr.sz.gov.cn/xxgk/qt/ztlm/zscqcjybh/zcwj/content/post_9072004.html	15%
Jiangsu	20%	2009	Plan for Intellectual Property Strategy in Jiangsu https://www.jiangsu.gov.cn/art/2009/1/5/art_46143_2543888.html	20%
Sichuan	15%	2006	Outline of the 11th Five-Year Plan for Intellectual Property Development in Sichuan https://202.61.89.171:8443/proxy/zwgk/zdgk/ghjh/201502/t20150206_15137.html	12%
Guangxi	10%	2006	Outline of the Medium- and Long-Term Plan for Scientific and Technology Development in Guangxi (2006-2020) https://most.gov.cn/ztzl/jqzzcx/zzcxmtbd/200604/t20060428_33042.html	Invention patent applications double by 2020, compared with 2005.
Zhejiang	18.75%	2006	Plan of the 11th Five-Year Plan for Patent Development in Zhejiang https://kjt.zj.gov.cn/art/2022/7/20/art_1229663286_59003705.html	Invention patent applications account for 15-20% of overall applications
Hainan	12.45%	2006	Outline of the 11th Five-Year Plan for Scientific and Technology Development in Hainan https://www.hainan.gov.cn/hainan/szfwj/200606/859eddfa25b142f98decaaa848d4a37c.shtml	Number of invention patents rise to 4,000 over five years and account for 30% of total
Shanxi	20%	2008	Plan for Intellectual Property Strategy in Shanxi (2008-2020) http://www.shaanxi.gov.cn/zfxxgk/fdzdgknr/zcwj/nszfwj/szf/202208/t20220808_2237647.html	Number of applications exceeds 15,000. Invention patents account for more than 40%
Inner Mongolia	34%	2006	Outline of the Medium- and Long-Term Plan for Scientific and Technology Development in Jiangxi (2006-2020) https://kjj.ordos.gov.cn/zwgk/201012/t20101229_275755.html	Invention patents account for more than 25% of overall applications
Xinjiang	25.48%	2011	Opinions on the Intellectual Property Strategy Promotion Project in Xinjiang (2011-2015) https://www.xinjiang.gov.cn/xinjiang/gfxwj/201108/a02102be65fa4bc090a3761d22873e8c.shtml	Invention patents account for more than 35% of 30,000 patent applications overall
Jiangxi	25%	2015	Plan for Intellectual Property Strategy in Jiangxi (2015-2020) http://www.nipso.cn/onews.asp?id=29354	25%
Henan	20%	2011	Opinions on the Patent Strategy Promotion Project in Henan https://www.henan.gov.cn/2011/04-29/237845.html	Number of patents per capita exceeds 1 by 2015

Fujian	15%	2010	Opinions on the Intellectual Property Strategy in Fujian https://www.fujian.gov.cn/zwgk/zfxxgk/szfwj/jgzz/kjwwzcwj/201002/t20100223_1183549.htm	15%
Guizhou	31%	2006	Outline of the Medium- and Long-Term Plan for Scientific and Technology Development in Guizhou (2006-2020) https://www.guizhou.gov.cn/zwgk/zfgb/gzszfgb/200608/t20060831_70515607.html	Invention patents account for more than 30% of total applications
Yunnan	55%	2007	Outline of the 11th Five-Year Plan for Intellectual Property Development in Yunnan https://www.yn.gov.cn/zwgk/zfxxgkpt/fdzdgknr/ghxx/zxgh/201903/t20190301_179293.html	Number of applications exceeds 16,000 and invention patents account for more than 30%
Anhui	30%	2006	Outline of the 11th Five-Year Plan for Scientific and Technology Development in Anhui https://www.ah.gov.cn/site/tpl/1931?contentId=795879	30%
Shandong	29%	2005	Outline of the Intellectual Property Strategy in Shandong (2005-2010) http://www.nipso.cn/onewsn.asp?id=14206	Invention patent applications account for 30% of overall applications
Shanxi	15%	2016	Outline of the 13th Five-Year Plan for Patent Development in Shanxi https://kjcyc.llu.edu.cn/info/1045/1189.htm	Number of patent applications doubles compared with 12th Five-Year Plan
Hunan	19%	2006	Outline of the 11th Five-Year Plan for Intellectual Property Development in Hunan https://www.hunan.gov.cn/hnszf/xxgk/fzgh/201212/t20121210_4902879.html	Growth rate of patent applications exceeds 15%. Invention patents account for 35%
Hebei	15%	2011	Outline of the 12th Five-Year Plan for Patent Development in Hebei https://hbdrc.hebei.gov.cn/gzdt/202403/t20240327_113247.html	15%
Qinghai	24%	2006	Outline of the 11th Five-Year Plan for Science and Technology Development in Qinghai https://wenku.baidu.com/view/ea48ffd9935f804d2b160b4e767f5acfa0c7832d.html?_wkts_=1726475749355	Number of patent applications exceeds 1,000. Invention patents account for 20%
Ningxia	30%	2011	Plan for the Intellectual Property Strategy in Ningxia https://www.most.gov.cn/dfkj/nx/zxdt/201111/t20111117_90900.html	30%
Hubei	20%	2006	Outline of the 11th Five-Year Plan for the Intellectual Property Development in Hubei https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fzscqj.hubei.gov.cn	Growth rate of patent applications exceeds 15%, and invention patents
Gansu	18.2%	2010	Outline of the 11th Five-Year Plan for the Intellectual Property Strategy in Gansu https://scjg.gansu.gov.cn/scjg/c110212/202106/8db20fc3955a40f18c22027abe2a3afc.shtml	Growth rate exceeds the average growth rate nationwide
Heilongjiang	8.6%	2011	Outline of the Intellectual Property Development in Heilongjiang (2011-2020) https://www.hlj.gov.cn/hlj/c108166/201111/c00_30643858.shtml	Number of invention patents exceeds 2.1 per capita by 2015
Jilin	32%	2011	Outline of the 12th Five-Year Plan for Science and Technology Development in Jilin http://kjt.jl.gov.cn/xxgk/lslm/ghjh/201604/t20160420_2200131.html	Number of patent approvals exceeds 10,000 by 2015, and invention patents account for 25%.
Liaoning	10%	2006	Outline of the 11th Five-Year Plan for Science and Technology Development in Liaoning https://kjt.ln.gov.cn/kjt/xxgk/kjgh/D0AA3F01D3B44DB38F59551B2E850CB1/index.shtml	10%
Tibet	N/A	N/A	N/A	N/A

Appendix 3: Monthly Trend of Patent Applications in Pseudo Year

Figure A1: Patent applications in pseudo year



Notes: This figure depicts the estimated results of Eq. (2). The dependent variable is the proportion of patent applications within a constructed pseudo year (combining the last two months of fiscal year *t* with the first ten months of fiscal year *t+1*). Panel (A) displays the monthly trend of all patent applications, while Panels (B) through (D) illustrate the trends for invention, utility model, and design patents, respectively.

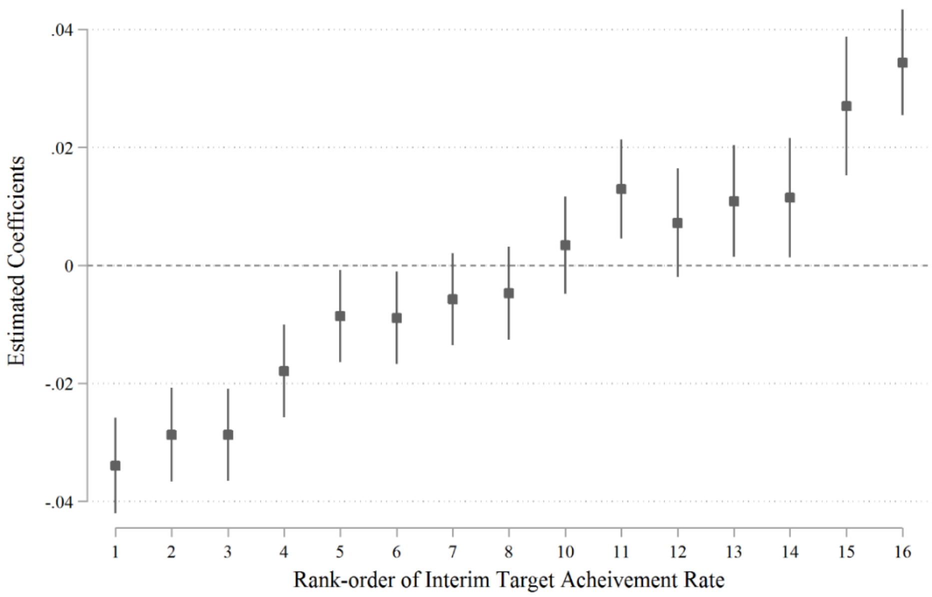
Appendix 4: Using Pure Rank for Relative Interim Performance

Table A3: Pure rank effects on year-end rush

	Baseline		Robustness Checks			
Dependent Var.:	(a)	(b)	(c)	(d)	(e)	(f)
YER	All patents	All patents	All patents	Invention patents	Utility model	Design patents
ITAR		-0.017***	-0.024***	-0.013***	-0.012***	-0.006***
		(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
$Rank^1$	-0.033***	-0.015***	-0.071***	-0.094***	-0.076***	-0.150***
	(0.004)	(0.005)	(0.009)	(0.016)	(0.009)	(0.014)
$Rank^2$	-0.028***	-0.017***	-0.063***	-0.089***	-0.071***	-0.124***
	(0.004)	(0.004)	(0.006)	(0.009)	(0.006)	(0.011)
$Rank^3$	-0.027***	-0.019***	-0.051***	-0.078***	-0.055***	-0.101***
	(0.004)	(0.004)	(0.005)	(0.008)	(0.006)	(0.010)
$Rank^4$	-0.017***	-0.011***	-0.038***	-0.063***	-0.044***	-0.092***
	(0.004)	(0.004)	(0.005)	(0.008)	(0.005)	(0.010)
$Rank^5$	-0.007*	-0.003	-0.029***	-0.051***	-0.032***	-0.082***
	(0.004)	(0.004)	(0.005)	(0.007)	(0.005)	(0.010)
$Rank^6$	-0.008**	-0.005	-0.026***	-0.036***	-0.020***	-0.067***
	(0.004)	(0.004)	(0.004)	(0.007)	(0.005)	(0.010)
$Rank^7$	-0.005	-0.003	-0.015***	-0.021***	-0.019***	-0.056***
	(0.004)	(0.004)	(0.004)	(0.007)	(0.005)	(0.010)
$Rank^8$	-0.003	-0.002	-0.006	-0.013*	-0.006	-0.023**
	(0.004)	(0.004)	(0.004)	(0.007)	(0.005)	(0.010)
$Rank^{10}$	0.004	0.004	0.013***	0.001	0.006	0.004
	(0.004)	(0.004)	(0.004)	(0.008)	(0.005)	(0.010)
$Rank^{11}$	0.014***	0.012***	0.019***	0.028***	0.024***	0.037***
	(0.004)	(0.004)	(0.005)	(0.008)	(0.005)	(0.011)
$Rank^{12}$	0.008*	0.005	0.028***	0.032***	0.025***	0.033***
	(0.005)	(0.005)	(0.005)	(0.009)	(0.006)	(0.012)
$Rank^{13}$	0.012**	0.009*	0.044***	0.050***	0.030***	0.073***
	(0.005)	(0.005)	(0.006)	(0.009)	(0.006)	(0.012)
$Rank^{14}$	0.013**	0.008	0.036***	0.077***	0.032***	0.099***
	(0.005)	(0.005)	(0.007)	(0.010)	(0.007)	(0.013)
$Rank^{15}$	0.028***	0.023***	0.041***	0.078***	0.042***	0.085***
	(0.006)	(0.006)	(0.008)	(0.012)	(0.008)	(0.016)
$Rank^{16}$	0.035***	0.028***	0.064***	0.112***	0.054***	0.162***
	(0.005)	(0.005)	(0.008)	(0.011)	(0.008)	(0.014)
Constant	0.224***	0.242***	0.267***	0.270***	0.251***	0.267***
	(0.003)	(0.004)	(0.004)	(0.006)	(0.004)	(0.007)
City & Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,267	9,267	9,267	9,165	9,267	8,462
R-squared	0.243	0.248	0.263	0.205	0.214	0.171

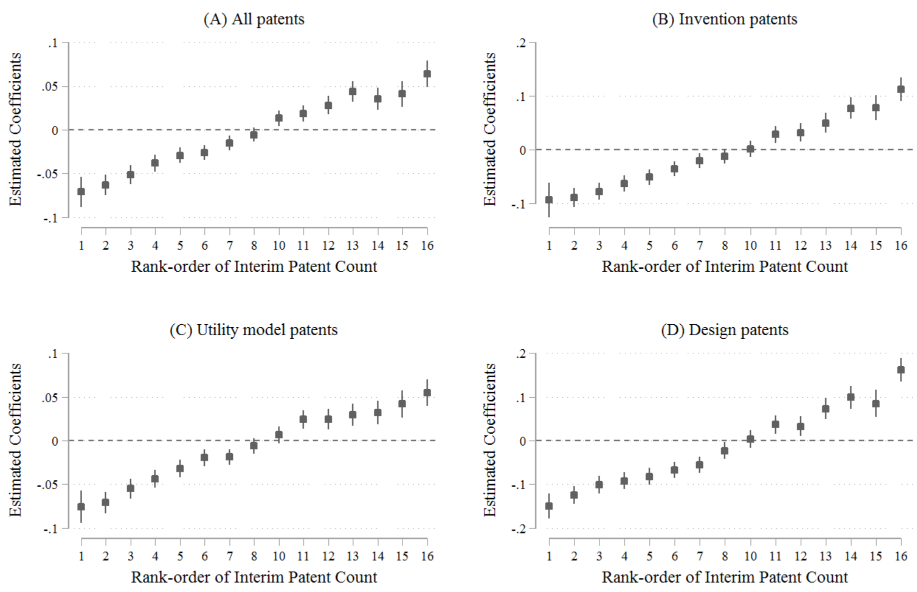
Notes: This table presents the estimated results from a variant of Eq. (3), using rank dummies based on pure rank. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. $Rank^9$ serves as the baseline group, and cities ranked beyond 16 are classified as rank 16.

Figure A2: Effect of pure rank on the year-end rush in patent applications



Notes: This figure visualizes the estimated results of a variant of Eq. (3), using rank dummies based on pure rank in the interim target achievement rate. Rank 9th serves as the baseline group, and cities ranked beyond 16 are classified as rank 16.

Figure A3: Alternative measure of pure rank based on number of patent applications



Notes: This figure depicts the estimated results of a variant of Eq. (3), using rank dummies based on pure rank. $Rank^9$ serves as the baseline group, and cities ranked beyond 16 are classified as rank 16. Panel (A) is based all types of patent applications, while Panels (B) through (D) focus on invention, utility model, and design patents, respectively.

Appendix 5: Effect of Rank Decline and Rank Advance

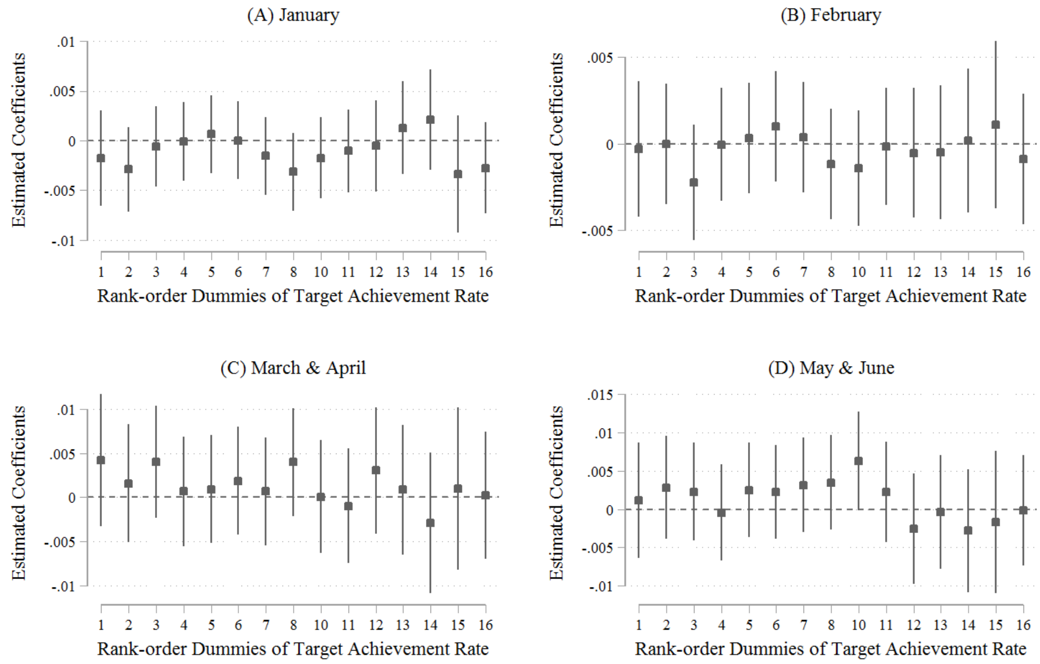
Table A4: Rank decline and advance

Dependent variable: *YER*	(a) All patents	(b) Invention patents	(c) Utility model patents	(d) Design patents
$ITAR$	-0.025***	-0.017***	-0.012***	-0.008***
	(0.002)	(0.001)	(0.001)	(0.001)
$Rank\_Decline$	0.015***	0.023***	0.017***	0.039***
	(0.002)	(0.004)	(0.002)	(0.005)
$Rank\_Advance$	-0.004*	-0.007*	-0.005**	-0.019***
	(0.002)	(0.004)	(0.002)	(0.005)
Constant	0.248***	0.246***	0.228***	0.220***
	(0.003)	(0.003)	(0.002)	(0.004)
City & Year FE	Yes	Yes	Yes	Yes
Observations	9,267	9,165	9,267	8,462
R-squared	0.244	0.174	0.196	0.131

Notes: This table presents the estimated results from a variant of Eq. (3), where rank order is replaced with the change in rank order. The dummy variable $Rank\_Decline$ ($Rank\_Advance$) is assigned a value of one if the rank of the interim target achievement rate declines (advances) compared to the previous year. Robust standard errors are reported in parentheses. ***, ** and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

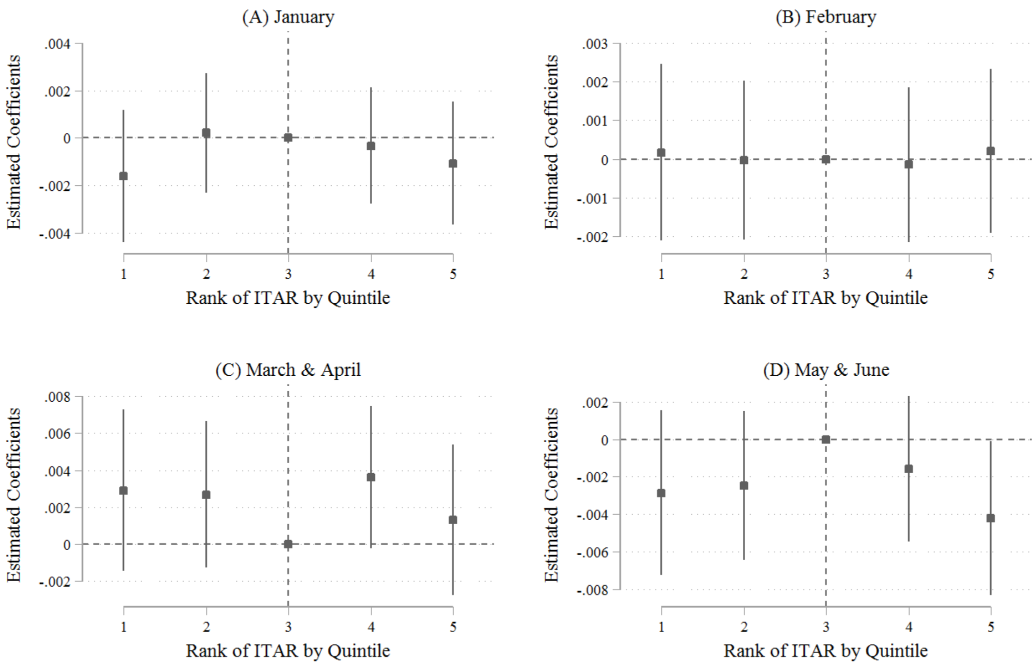
Appendix 6: Placebo Test

Figure A4: Patent applications in the early months of next year



Notes: This figure illustrates the estimated coefficients of a variant of Eq. (3), using rank dummies based on pure rank. The placebo dependent variables are calculated based on patent applications from early months of the following year. $Rank^9$ serves as the baseline group, and cities ranked beyond 16 are classified as rank 16.

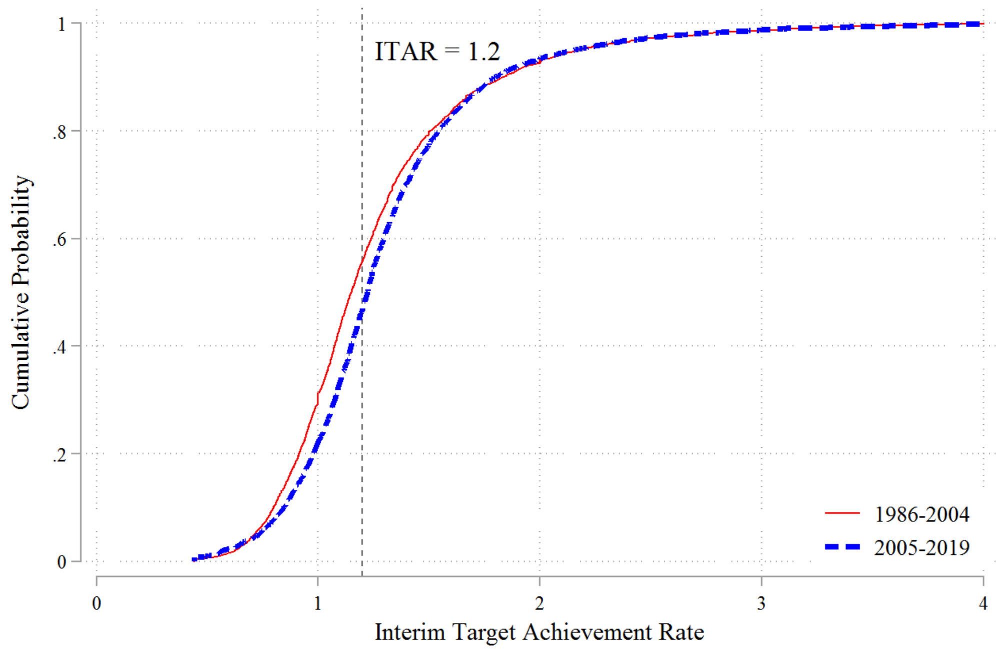
Figure A5: Placebo test: patent applications in early months of the next year



Notes: This figure illustrates the estimated coefficients of the quintile rank dummies in Eq. (3), using patent applications from early months of the following year to construct the pseudo outcome variables. The ranking is based on the interim target achievement rate (ITAR), with cities in the third quintile within their provinces serving as the reference group.

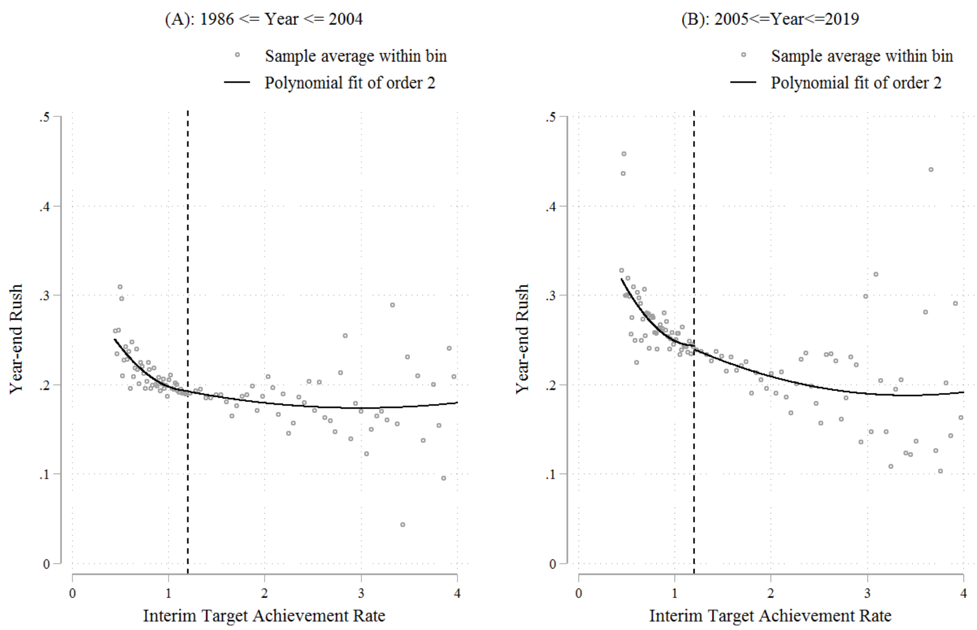
Appendix 7: Regularities for *ITAR*

Figure A6: Cumulative distribution of *ITAR*



Notes: This figure displays the cumulative density distributions of the interim target achievement rate for the subsample periods of 1986-2004 and 2005-2019, respectively.

Figure A7: Target achievement rate and year-end rush



Notes: This figure illustrates the relationship between the year-end rush and the interim target achievement rate (*ITAR*). Polynomial functions are fitted to the subsamples of cities with an *ITAR* either below or above 1.2 for the periods 1986-2004 and 2005-2019.

Table A5: Patents filed by agencies

	(1) All patents	(2) Invention	(3) Utility model	(4) Design
Month_1	-0.020***	-0.020***	-0.022***	-0.014**
	(0.004)	(0.005)	(0.004)	(0.006)
Month_2	-0.031***	-0.033***	-0.029***	-0.009
	(0.004)	(0.005)	(0.004)	(0.006)
Month_3	-0.021***	-0.023***	-0.023***	-0.009*
	(0.004)	(0.005)	(0.004)	(0.006)
Month_4	-0.009**	-0.006	-0.010**	-0.001
	(0.004)	(0.005)	(0.004)	(0.005)
Month_5	-0.016***	-0.018***	-0.014***	-0.007
	(0.004)	(0.005)	(0.004)	(0.006)
Month_6	-0.002	-0.001	-0.002	-0.002
	(0.004)	(0.005)	(0.004)	(0.006)
Month_8	-0.001	0.001	0.001	0.003
	(0.004)	(0.005)	(0.004)	(0.006)
Month_9	0.006*	0.008	0.007*	0.005
	(0.004)	(0.005)	(0.004)	(0.005)
Month_10	-0.014***	-0.015***	-0.012***	-0.003
	(0.004)	(0.005)	(0.004)	(0.006)
Month_11	0.001	0.001	0.004	0.004
	(0.004)	(0.005)	(0.004)	(0.005)
Month_12	0.011***	0.019***	0.010**	0.014**
	(0.004)	(0.005)	(0.004)	(0.005)
Constant	0.654***	0.632***	0.672***	0.649***
	(0.003)	(0.004)	(0.003)	(0.004)
City & Year FE	Yes	Yes	Yes	Yes
Observations	122,475	93,974	115,074	79,102
R-squared	0.191	0.171	0.172	0.193

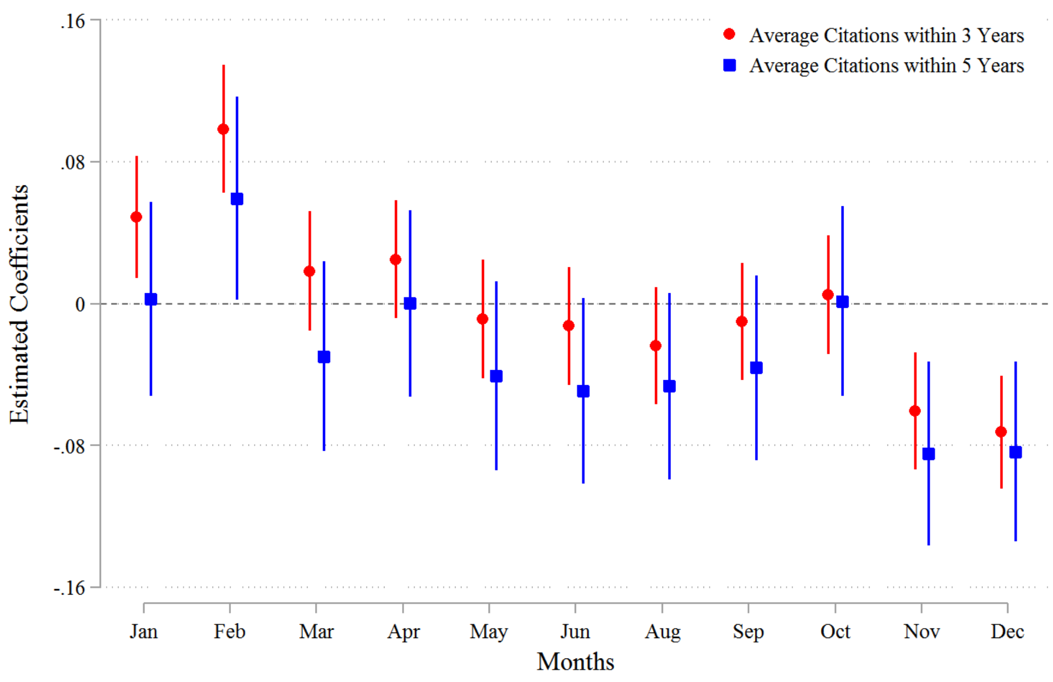
Notes: This table presents the estimated results of Eq. (2), with the proportion of patents filed by patent agencies as the dependent variable. Robust standard errors are reported in the parentheses. ***, ** and * respectively denote statistical significance at the 1%, 5%, and 10% levels. July is taken as the baseline group, and Month_7 is omitted from the regressions.

Appendix 8: The Practice of the Year-End Rush

There are two potential channels to increase patent filings at the year-end. One, as mentioned in the main text, is to file low-quality patents that otherwise would not have been filed. If this is the channel, then the average quality of patents filed at the year-end will be lower. To empirically examine this, we again estimate the monthly trend in Eq. (2), taking the dependent variable as the average number of forward citations received within three or five years after the date of application. This quality measure is calculated by dividing the total number of forward citations by the total number of patent applications for each city-year-month cell. We focus on invention patents, as the quality of the invention patents is the main concern of the Chinese government. Figure A8 shows that patents filed in the last two months of the year are of substantially lower quality compared to those filed in other months. This holds regardless of whether citations are measured in terms of three years or five years. The results confirm that the year-end rush is driven by the filing of low-quality innovations, a result consistent with Sun et al. (2021).

Another potential channel of increasing year-end filings is to bring forward the applications for innovations originally intended for early in the next year at a normal pace to the end of the current year. The deep trough observed in January and February in the monthly trend shown in Figure 1 seems to suggest this possibility. To empirically test this channel, we calculate the proportion of a city's applications in the first two months relative to the first six months of year *t*, denoted as x_{ct}, and then compute the correlation between x_{ct} and $YER_{c(t-1)}$. The value of x_{ct} is intended to measure how year *t*'s applications in the first six months are concentrated in the first two months. If the way in which a city engages in the year-end rush in year *t-1* is by advancing patents for the next year early, there should be a negative relationship between x_{ct} and $YER_{c(t-1)}$. It turns out that there is no significant correlation between them (if anything, the correlation coefficient is 0.043, and is not statistically significant). The placebo tests in Appendix 6 also reject the hypothesis that the year-end rush is due to bringing the next year's patent applications forward to the end of the current year. We thus conclude that the cities rush applications at the year-end mainly by filing low-quality innovations which otherwise would not have been filed.

Figure A8: The quality of patents filed in different months



Notes: This figure depicts the estimated results of Eq. (2), using the average number of forward citations for invention patents within 3 years and 5 years, respectively, as the dependent variables.