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A screening perspective on experimental zones☆

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ABSTRACT

Experimentation, or, setting experimental zones, is essential to many countries' economic success, especially China. Traditional explanations suggest that setting experimental zones is for loss-control or resistance-minimization. In this paper, we provide an alternative rationale that emphasizes the "screening effect" of experimental zones: when proposals—whose qualities are unknown to the central government (principal)—are proposed by informed local officials (agents), providing support gradually over time rather than all at once reduces the local governments' incentives to propose low-quality projects, resulting in a higher proportion of high-quality projects in equilibrium. The main tradeoff facing the central government is between better screening and delayed implementation of good projects. We show that when the central government is more patient, or good projects exhibit a larger positive externality, the reform speed, measured by initial support level, decreases while the reform scale, measured by the number of approved projects, increases. As the negative consequence of bad projects becomes higher, however, both reform speed and scale decrease, implying a steady but stagnant reform. By contrast, in a benchmark case without information asymmetry between the central and local governments, the optimal initial support is either minimal or full and does not depend on the externality.

1. Introduction

Experimental zones are widespread across economies. Nearly three-quarters of all countries have such zones (Boyenge, 2007), and they are common in developing as well as developed countries (Grant, 2020). Moreover, many researchers attribute China's huge economic success to the experience of setting experimental zones (e.g., Xu, 2011). Understanding the rationale behind the success of experimental zones is thus essential.

Traditional literature focuses on the benefits of experimental zones as cost-saving (by trial and error) and policy laboratories. In this paper, we propose an alternative theory from the incentive perspective based on two features of experimental zones that are essential in China's experience. First, while local authorities have vital information of potential projects, they also need support from the central authority. The combination of bottom-up proposal and top-down support is a feature that is largely missing in the literature.[1] Second, the support is provided gradually over time: even in one local area, the support is provided partially at the beginning, with small

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[1] Callander and Harstad (2015) is an exception.

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fractions rather than all at once.

There are many examples of the bottom-up then top-down reforms and providing support over time. The free trade zone (FTZ) experiment is a key example. The trial started from Shanghai in 2013 and gradually spread to the other regions in China. As of 2019, there were 21 provinces (municipalities) with FTZs, which replicated and extended the experience from Shanghai (as shown in Fig. 1a). Even in Shanghai, the FTZ experienced two waves of expansion after 2013, from the initial area of 29 km^2 to 240 km^2 in 2019, with the plan of further expansion in the future (as shown in Fig. 1b).

Another example is China's land reform experiments, started in Chengdu and Chongqing, as part of the national comprehensive rural-urban reform pilot zone (established in June 2007). The land property right reform, for instance, was initiated in several small areas in Chengdu in 2008,[2] received further approval/support from the central government to be implemented citywide in Chengdu in 2009–10, and then expanded to the rest 164 counties in Sichuan province in 2016.[3] In other words, even within an experiment zone, a reform still proceeds in stages. Then, with the successful experience of piloting regions, the land reform expands to 2828 counties country-wide in another five years (from 2013 to 2018).[4]

The bottom-up approach naturally brings up an agency-issue, i.e., local governments may not have the incentives to propose the "right" projects. We emphasize in this paper that the second feature, i.e., support given gradually rather than all at once, may help the central government solve the agency issue at least partially.

Specifically, we build a principal-agent model in which each agent (local government) has a project and chooses whether to propose it. The friction is asymmetric information: the quality of a projects is privately known by the local government. While the central government concerns the quality of a project, the local governments only care about the amount of supports that they can get.[5]

A key equilibrium feature of this model is *providing support gradually over time*: supports to each approved project is provided gradually in multiple periods, rather than all at once. In particular, besides from choosing the *reform scale* (i.e., how many proposals to approve), the central government also chooses the *reform speed* (i.e., how much support to provide in an initial, "experimenting," period). After an experiment is carried out, the quality of the corresponding project will be revealed, and the central government may continue to support good projects.

The central government, when choosing the initial supporting level, faces the tradeoff between better screening and delayed implementation of projects. A smaller initial support lowers the incentives of the local governments to propose bad projects, which leads to better screening. However, it also means that a larger portion of the (good) projects have to be delayed.

We show that when the central government is more patient or the good projects have larger externality, the equilibrium reform speed decreases and the reform scale increases, resulting in a better screening and larger-scale reform. However, when central authority suffers more from a bad project, both the reform speed and scale decrease, implying a steady but relatively stagnant reform.

The previous literature already noticed the important role played by the central government in shaping local officials' incentives (e.g., Blanchard and Shleifer (2001)). Our paper complements the literature by assuming that the central government has limited reward and punishment ability. Our mechanism also echoes what Xu (2011) described the Chinese system as a "regionally decentralized authoritarian regime." Relatedly, Qian, Roland, and Xu (2006) compare M-form and U-form organization and examine their impact on experimentation. We take the organizational form as given, and focus on the potential impact of choosing experimentation policy on local officials' incentives. We also add to the more recent literature that tries to unravel the economic success of autocracies (Luo & Przeworski, 2019).

This paper is also related with a large literature on decentralization (e.g., Treisman (1999), Cai and Treisman (2009), Huang, Li, Ma, and Xu (2017), Cheng and Li (2019), Jia, Liang, and Ma (2021)). Different from that literature, our focus is not on setting the optimal degree of decentralization, but on the optimal mechanism that a central government can use to elicit information when its punishment power is limited.

2. Model setup

There are one central government (principal, P) and several local governments (agents, A_1, A_2…) in the economy.[6] Each local government has one potential reform proposal and privately knows its quality ("type"), either good or bad: $\theta_i \in \{H, L\}$ are i.i.d. with a common prior $\mathrm{P}(\theta_i = H) = p$.[7]

The proposals are bottom-up, while the supports are top-down. In particular, each local government chooses whether to propose their proposal, and the central government chooses which and how many projects to approve and provide supports according to a precommitted policy.

There is a misalignment of incentives: while the central government concerns with the quality of the projects, each local government only cares about the total amount of support they can get from the central government.[8]

[2] The rural land titling project, for instance, was piloted in Heming Village, Dujiangyan County in March 2008, and later extended to other areas in Chengdu: till 2014, Chengdu issued 8.83 million land title certificates (Lu & Yao, 2018).

[3] NSD Study Group on China's Land Reform, 2010.

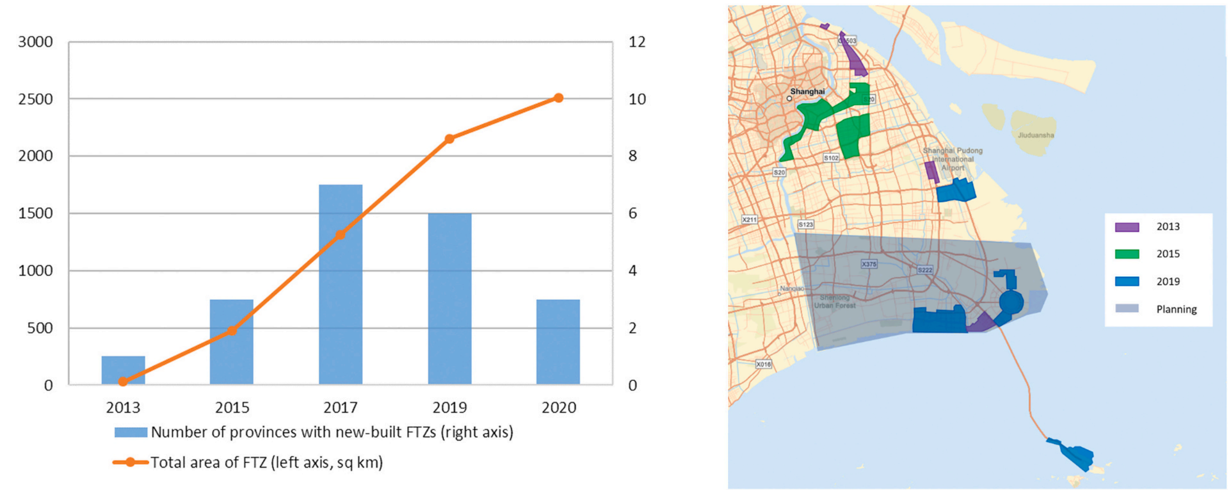
[4] Yao and Wen (2019).

[5] We relax this assumption in Section 6.

[6] We refer central government as "she" and local government as "he" in this paper.

[7] We discuss the theoretical results in an alternative (benchmark) case without information asymmetry in Section 5.

[8] Our results would still hold if the local governments care about the quality of the project as well. See Section 6.



(a) FTZ in China.

(b) FTZ in Shanghai

Fig. 1. Expansion of Free Trade Zone (FTZ).
Note: Hainan Free Trade Zone is not included in Panel (a). In 2018, the whole island was set as Free Trade Zone with an area of over 33,000 km2. Data source: Central government website and Shanghai government website.

The central government supports each selected project over time, specified by an *experiment policy* $(s_1, s_2(\cdot))$, where $s_1 \in [0,1]$ is the initial support (as an experiment), i.e., before information about project quality reveals, and $s_2 : \{H, L\} \to [0, 1 - s_1]$ determines the continuing support on a project after its information reveals.[9]

Timing of the game is summarized as follows:

- $t = 0$: Central government P announces the experiment policy $(s_1, s_2(\cdot))$.
- $t = 1$ (Experiment Period): Each local government A_i observes $\theta_i \in \{H, L\}$ and chooses whether or not to propose their project, let $a_i \in \{1, 0\}$, and $a_i = 1$ means a project is proposed and $a_i = 0$ means the opposite. Among proposed projects, central government approves a set of projects I_n. Each project $i \in I_n$ is then carried out with support level s_1.
- $t = 2$ (Promotion Period): the quality of each approved project, θ_{i_k}, is revealed to the principal, who provides the further support $s_2(\theta_{i_k}) \in [0, 1 - s_1]$.

A local government A_i cares about the total support that he can get from the central government[10] (when the project is approved, $i \in I_n$):

$$u_i(s_1, s_2(\cdot); \theta_i) = s_1 + s_2(\theta_i) - c_i,$$

where c_i denotes the cost of carrying out a project,[11] i.i.d with a continuous cdf $F(c_i)$ on [0,1].[12] Note that local governments have limited liability, so that the central government cannot impose additional punishments.[13]

The benefits of an approved project $i \in I_n$ to the central government P is as following:

$$\pi_i(s_1, s_2(\cdot); \theta_i) = v_{\theta_i} \cdot [s_1 + \beta s_2(\theta_i)] + E \cdot 1\{\theta_i = H\},$$

where $v_{\theta_i} \in \{\nu_H, \nu_L\}$ and $\nu_H > 0 > \nu_L$. $\beta < 1$ is the central government's discount factor[14]; and $E \geq 0$ represents the externality of a good

[9] We may also interpret s_1 as the "legal support" granted to the local officials: $s_1 = 0$ means that the project is allowed yet without additional legal flexibility, and $s_1 = 1$ means the projects can be executed fully at the local officials' discretion.

[10] We assume full revelation of information in the baseline model. We could also allow for partial information revelation and the main results hold. See Section 6.2 for a detailed discussion.

[11] This could incorporate expenses of executing projects, for example land entitlement needs a large amount of money to delineate land borders, etc. And note that here we assume there is no cost of proposing.

[12] We can further allow the cost functions to be quality-dependent, and our results hold in this case as well. See Section 6.4 for more details.

[13] We relax this assumption in section 6.1 and see what happens when the central government can reward/punish local governments.

[14] To simplify notations, we assume local officials do not discount. See section 6.3 for a relax of this assumption.

project, e.g., the benefits from promoting it to the other regions.[15]

Finally, P pays a total cost $C(n)$ in executing projects,[16] where n is the number of projects approved. We assume $C'(\cdot) > 0$, $C''(\cdot) > 0$, $C(0) = 0$, $C'(0) = 0$ and $C'(\infty) = \infty$. Thus, the central government's *ex post* payoff when selecting projects I_n is

$$\Pi\left(s_1, s_2(\cdot), I_n; \{\theta_i\}_{i \in I_n}\right) = \sum_{i \in I_n} \{v_{\theta_i} \cdot [s_1 + \beta s_2(\theta_i)] + E \cdot 1\{\theta_i = H\}\} - C(n).$$

3. Equilibrium analysis

We use backward induction. At $t = 2$, since $\nu_H > 0 > \nu_L$, it is optimal to fully continue a project whenever it is good, i.e., $s_2{}^*(H) = 1 - s_1$, and abandon a project when it is bad, i.e., $s_2{}^*(L) = 0$. Therefore, given s_1, a selected project i brings the following payoffs, respectively, to local government A_i and central government P:

$$u_i\left(s_1, s_2^*(\cdot); \theta_i\right) = s_1 + (1 - s_1) \cdot 1\{\theta_i = H\} - c_i, \tag{1}$$

$$\pi\left(s_1, s_2^*(\cdot); \theta_i\right) = v_{\theta_i} \cdot [s_1 + \beta(1 - s_1) \cdot 1\{\theta_i = H\}] + E s_2^*(\cdot) 1\{\theta_i = H\}.$$

At $t = 1$, since local governments (and proposals) are symmetric *ex ante*, the central government only chooses the total number $n \in R_+$,[17] such that n projects are randomly selected in I_n.

Given policy $(s_1, s_2{}^*(\cdot))$, local government A_i's optimal choice is to propose the project if $u_i(s_1, s_2{}^*(\cdot); \theta_i) \geq 0$, as summarized in the following lemma:

Lemma 1. (Local government's strategy and the screening): *Given the initial support s_i, the local government's strategy of making proposal is as following:*

$$a_i^*(s_i) = \begin{cases} 0 & \text{if } \theta_i = L \text{ and } c_i > s_1 \\ 1 & \text{otherwise} \end{cases}, \forall i.$$

Therefore, the posterior of the H-type among the proposed projects is

$$\sigma(s_1) = Pr\{\theta_i = H | s_1\} = \frac{p}{p + (1 - p)F(s_1)}. \tag{2}$$

Finally, partial initial support is an effective screening device: $\sigma(s_1) > p\ \forall s_1 < 1$ and $\sigma(s_1)$ decreases in s_1.

Lemma 1 states two results:

First, the local government's strategy is such that H-type projects are always proposed, and L-type projects are proposed whenever their costs are lower than a threshold[18], i.e., $c_i \leq s_1$.

Second, partial initial support ($s_1 < 1$) is an effective screening device, so that the posterior of the H-type is higher than the prior and is decreasing in s_1.

Now we turn to the central government's optimal decision. Her *ex-ante* benefit, per project, is as following:

$$\mathrm{E}\pi^*(s_1) = \mathrm{E}\pi\left(s_1 s_2^*\right) = \sigma(s_1)\{v_H[s_1 + \beta(1 - s_1)] + E\} + (1 - \sigma(s_1)) v_L s_1, \tag{3}$$

and her payoff from all projects is:

$$\mathrm{E}\Pi^*(n, s_1) = n\mathrm{E}\pi^*(s_1) - C(n), \tag{4}$$

This leads to the following characterization of equilibrium:

Proposition 1. **(*Equilibrium*):** *There exists a Perfect Bayesian Equilibrium (PBE), $(s_1{}^*, s_2{}^*(\cdot), n^*; a_i{}^*(s_1{}^*))$, in this game, such that*

1) $s_2{}^*(\theta_{i_k}) = (1 - s_1{}^*) \cdot 1\{\theta_{i_k} = H\}$
2) $s_1{}^* \in argmax_{s_1 \in [0,1]} E\pi^*(s_1)$
3) $n^* \in argmax_{n > 0} E\Pi^*(n, s_1{}^*) \equiv nE\pi^*(s_1) - C(n)$
4) The local government A_i follows the strategy $a_i{}^*(s_1{}^*)$ (as described in Lemma 1)

Proof: all proofs are in the Appendix.

When choosing the initial support s_1, the central government faces a key tradeoff between the screening of projects and delayed implementation of (good) projects: A decrease in s_1 leads to better screening (since the posterior of H-type becomes larger) but also a larger portion of good project is delayed to the second period. An illustrating example and figure is presented in Appendix II.

[15] We remark that ν_H and E serve different roles: the former is the value of a (good) project itself, confined only to region i, while E captures the spill over to other regions.

[16] The cost captures the efforts needed to persuade his political partners and/or overcome the impediments from his opponents or the ideological stickiness. Moreover, we allow a more general interpretation of central government's cost function, and we discuss it in more detail in Section 6.5.

[17] To simplify notations, we treat $n \geq 0$ as a continuous variable. This can be viewed as the expected number of projects.

[18] A L-type projects with $c_L = s_1$ is indifferent between proposing or not. This is a measure zero event and hence does not affect the posterior.

4. The determinants of reform speed and scale

4.1. Theoretical investigations: comparative statics results

In this part, we discuss comparative statics. Recall that reform speed is captured by the initial support level, s_1*, and reform scale is captured by the number of projects supported, n*.

To apply the techniques of monotone comparative statics (e.g., Milgrom & Shannon, 1994), we first introduce some useful definitions.

Definition 1. (Increase difference) *A function $F : X \times T \to \mathbb{R}$ has increasing difference (ID) in (x, t), if all $x, x' \in X$ and $t, t' \in T$ such that $x > x'$ and $t > t'$, $F(x', t') - F(x, t') \geq F(x', t) - F(x, t)$.*[19]

Definition 2. (Set-order) *A set $S \subseteqq \mathbb{R}$ is bigger than $T \subseteqq \mathbb{R}$, denoted $S \geq_S T$, if for every $x \in S$ and $y \in T$, $y \geq x$ implies $y \in S$ and $x \in T$.*[20]

We provide the following property regarding the key pairs of parameters:

Lemma 2. (Increasing Differences) *Central government's expected equilibrium benefit from each selected project, $E\pi$*, has increasing differences in each of following combinations of parameters: $(-s_1, \beta)$; $(-s_1, E)$; and $(-s_1, v_L)$.*

With these preparations, we are now ready to state our main comparative statics results.

Proposition 2. (Comparative Statics *w.r.t.* β, E and $|v_L|$): *In equilibrium:*

1. *Reform speed, i.e., the initial support s_1*, decreases (in set-order) in the central government's time preference β, externality E, and absolute value of disutility $|v_L|$, for $\beta \in (0, 1)$ and $E > 0$.*
2. *Reform scale, i.e., equilibrium number of approved projects, n*, increases in β and E and decreases in $|v_L|$;*
3. *Central government's benefit per project $E\pi^*(s_1^*)$ and total expected benefits $E\Pi^*(n^*, s_1^*)$ strictly increase in β and E; and strictly decrease in $|v_L|$.*

Intuitively, when central government becomes more patient, he is more willing to delay the support of projects until information fully reveals and, therefore, can obtain better screening and this further leads to more projects being approved (comparative statics concerning β). Likewise, an increase in the externality E results in more benefits from identifying good projects, and consequently, other things given, there are larger benefits from screening (a lower s_1*) and again, an increase in n*. Therefore, in response to change in β or E, reform speed and scale move in opposite directions.

On the other hand, the graver the negative consequence of a bad project, captured by an increase in $|v_L|$, calls for a better screening and thus lowers s_1* and also reduces n*; that is, the reform speed and scale both decrease, resulting in a steady but stagnant reform.

4.2. Related anecdotal evidence

To better relate our main theoretical predictions (Propositions 1 and 2) to reality, we discuss several examples.

4.2.1. Health code (Jiankangma)

The first example is about the comparative statics result on *reform speed*. Consider the experiment and spread of Health code app (Jiankangma). To cope with the surge of cases during the early outbreak of COVID-19, the central government announced the emergent status and local governments took firm action to monitor the spread of the virus. The municipal government of Hangzhou cooperated with Ant Financial and launched the first version of Health code in Alipay (Zhifubao) on February 11, 2020, only 19 days after the lockdown of Wuhan city. 4 days later, the service of Health code App quickly expanded to 9 of 11 prefectural cities in Zhejiang Province and over 90% residents in the province installed Health Code in their Alipay within half a month. On February 16, under the guidance of the central government, Health code was promoted to the whole country to enhance surveillance of COVID-19 nationwide. Around the same time, the municipal government of Shenzhen also launched Weixin version of Health code app with Tencent, which later quickly covered around 1 billion population in the country within 100 days after its launch.[21]

The urgency of a reform calls for a higher reform speed. In this example, the urgent need of epidemiological surveillance corresponds to a low β, i.e., a very impatient central government. As our theory predicts (Proposition 2, part 1), a decrease in β would boost the initial support from the central government (s_1 in our model), represented by the large support given by the central government in the early, experimenting period in this example.

4.2.2. Reform scale across sectors

Our second example illustrates the determinants of *reform scale*, i.e., the number of projects approved, by comparing experimental

[19] When F is twice continuous differentiable, then ID is equivalent to $\frac{\partial^2 F}{\partial x \partial t} \geq 0$.

[20] Note we only need this when there might be multiple equilibrium values.

[21] China News, May 19, 2020, "Tencent Jiankangma upgraded to 'City Code', serving 1 billion uses in 100 days after the launch", https://www.chinanews.com.cn/business/2020/05-19/9188718.shtml.

zones in two sectors, agriculture and fishery. In late 1980s and early 1990s, a series of reforms were implemented in rural areas. The experimental zones were divided in two types, those in agriculture sectors and the ones in fishery sectors. Although both types were under the guidance of the same authority, Rural Development Research Center, their reform scale differed substantially. In particular, the agriculture sector witnessed a much larger reform scale: from year 1987 to 1992, at least 30 experimental zones were approved by the central government, covering 160 counties in 21 provinces (municipalities), in 11 policy documents. Whereas in the same period, only two fishery experimental zones were set up (in Shanwei, Guangdong province and Huanghua, Hebei province, respectively).[22]

Our theory provides a new perspective to look at the abovementioned difference: the agriculture reforms, once succeeded, have much larger externality, E, than the fishery ones; while the former may apply to the entire country, the latter type only contribute to the coastal areas. This is consistent with our prediction (Proposition 2, part 2) that a larger externality E increases the reform scale.

4.2.3. Reform scale over time

Our third example continues the discussion on reform scale. We examine the number of experimental projects approved over time and relate the pattern to relevant payoff parameters in the model.

Fig. 2 plots the number of experiments and the inflation rate over time, where high inflation is used as a proxy of the gravity of bad consequence from a failed reform, and in our model, that corresponds to a high $|v_L|$. The observation is that each period of high-inflation is followed by a relatively stagnant period of reforms. This is consistent with our comparative statics result w.r.t. $|v_L|$: high inflation raises the costs of reform failures and is related with a smaller reform scale, n^*.

5. Discussion: a benchmark without information asymmetry

To provide a better perspective on our theoretical results, we discuss how our theory differs from previous rationales for experimental zones, namely, *loss-control*: the initial support is wasted when the project is bad and, therefore, having a small initial amount reduces such loss. In the loss-control theory, there is no information asymmetry between the central and local agencies: neither the central nor the local government knows the project quality *ex ante*. Whereas in our theory, information asymmetry is the main friction and calls for screening which is provided by gradual support over time. In this part we show that with and without information asymmetry lead to a series of distinct implications.

To capture the loss-control rationale that is without information asymmetry, consider the following benchmark case. In particular, the agent does not observe the project quality $\theta_i \in \{H, L\}$ in advance (at $t = 1$), and the quality information will be revealed to both parties after the experiment period (at the beginning of $t = 2$). Other settings of the model remain unchanged.

In this benchmark case, each local government decides whether to propose a project with the prior probability p (that the project is of high quality). Thus,

$$u_i\left(s_1 s_2^*(\cdot)\right) = s_1 + p(1 - s_1) - c_i.$$

Therefore, a local government, i, proposes its project iff $c_i \leq s_1 + p(1 - s_1)$.

The central government randomly chooses n^b projects to support and, importantly, the fraction of high-quality projects in the proposed pool is p, independent of s_1 (again because local governments do not know project quality in advance either).

The central government's maximization problem becomes:

$$\max_{s_1 \in [01]} E\pi(s_1) = p\{v_H[s_1 + \beta(1 - s_1)] + E\} + (1 - p)v_L s_1,$$

which leads to the following optimal policy:

Proposition 3. (Optimal initial support level without information asymmetry): *Consider the benchmark case in which the local governments do not have information advantage about the project quality. The reform regime is bang-bang and not gradual.*

In particular, the optimal initial support level, s_1, is*

$$s_1^b = 1 \text{ if } \left|\frac{v_H}{v_L}\right\rangle \frac{1-p}{1-\beta}, s_1^b = 0 \text{ otherwise}.$$

That is, it is either minimal initial support ($s_1^b = 0$), or full support ($s_1^b = 1$).

Furthermore, the central government's choice of optimal initial support does not depend on the project externality E.

Remark: Comparing the results in our model (Propositions 1 and 2) and the benchmark case (Proposition 3), we note at least two major differences, both are driven by the screening perspective (based on the information asymmetry between central and local governments):

[22] Source: PKULaw.com.

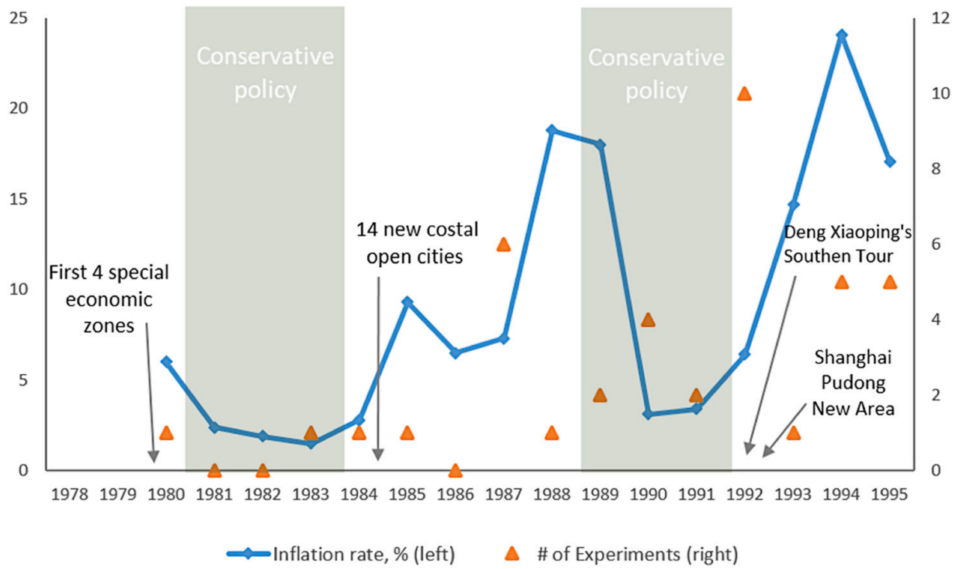


Fig. 2. China's reform policies over time.
Source: data on inflation rate is from the website of National Bureau of Statistics of China; data on the number of experiments is from Wang and Yang (2021).

- Our model features gradual support over time, captured by an interior solution of the initial support, $0 < s_1 < 1$ (Proposition 1); whereas this never occurs in the benchmark case without information asymmetry: the reform regime is bang-bang with either minimal or full initial supports.[23]
- In our model with information asymmetry, the initial support *decreases* in the externality E, due to the benefits of better screening (Proposition 2); while the optimal initial support level does not depend on E in the benchmark case.

6. Extensions

In section 4, we set the model as concise as possible to illustrate the screening effect of providing support over time. The goal of this part is to show that our main results are robust under alternative modeling choices.

Recall that the main results include:

- Partial initial support, $s_1 < 1$, is effective in incentivizing the local governments' proposing of good projects; consequently, the posterior of H-type projects is higher than the prior p and is decreasing in s_1 (Lemma 1)
- Equilibrium characterization (Proposition 1)
- Comparative statics results w.r.t. β, E and $|v_L|$ (Lemma 2, Proposition 2).

In the following we extend the baseline model in various directions and show the robustness of the above results.

6.1. *Local government's quality-dependent payoffs and limited liability*

In the baseline model we assume that the central government concerns the quality of the project, while the local governments only care about with the support that they receive. Here, we relax the assumption in two directions:

- We allow for the local governments' payoffs to depend on project quality. Particularly, a local government gets some intrinsic payoff that is quality-dependent, $\alpha_{\theta_i} \geq 0$, once their project is supported.
- We allow the central government to reward/punish projects. That is, we relax the limited liability assumption. In particular, the central government can reward a H-type project at an amount $R \geq 0$, and punish a L-type project at an amount $P \geq 0$, at $t = 2$.

These two extensions, while through very different channels, lead to similar effects mathematically:

[23] The only exception is the knife-edge case $|v_H/v_L| = (1-p)/(1-\beta)$, where the principal is indifferent between any $s_1^b \in [0,1]$. In addition, we acknowledge that the bang-bang feature depends on the functional forms and it is not impossible to generate interior equilibrium initial support even without asymmetric information.

Once the project quality is revealed, it is still optimal for the central government to choose $s_2(\theta_i) = (1 - s_1)1\{\theta_i = H\}$, i.e., to continue the support on the H-type projects (plus a reward) and abandon the L-type projects (plus a punishment).

Thus, the local government's equilibrium payoff, the previous Eq. (1), becomes:

$$u_i(s_1, s_2(\cdot);\theta_i) = \begin{cases} 1 + \alpha_H + R - c_i & \text{if} \quad \theta_i = H \\ s_1 + \alpha_L - P - c_i & \text{if} \quad \theta_i = L \end{cases} \tag{1'}$$

Lemma 1 still holds, with an updated threshold for the L-type:[24]

$$a_i^*(s_i) = \begin{cases} 0 & \text{if } \theta_i = L \text{ and } c_i > s_1 + \alpha_L - P \\ 1 & \text{otherwise} \end{cases}, \forall i$$

The posterior of the H-type becomes:

$$\sigma(s_1 + \alpha_L - P) = Pr\{\theta_i = H | s_1 + \alpha_L - P\} = \frac{p}{p + (1-p)F(max\{s_1 + \alpha_L - P, 0\})} \tag{2'}$$

which exceeds p and still decreases in s_1. That is, screening remains effective.

The central government's equilibrium payoff, the previous Eq. (3), is updated as:

$$\text{E}\pi^*(s_1) = \sigma(s_1 + \alpha_L - P)\{v_H[s_1 + \beta(1 - s_1)] + E\} + [1 - \sigma(s_1 + \alpha_L - P)]v_L s_1 \tag{3'}$$

Equilibrium characterization (Proposition 1) holds with the updated $\text{E}\pi^*(s_1)$.

Comparative statics w.r.t. β, E and $|v_L|$ (Lemma 2 and Proposition 2) remain the same, since neither α_L nor P alter the nature of increasing differences for pairs $(-s_1, \beta)$, $(-s_1, E)$, and $(-s_1, |v_L|)$ in Eq. (3′).

6.2. Partial information revelation after experiments

In the baseline model, we assume that the quality of a project is fully revealed after experiments (at $t = 2$). Here we relax this by assuming partial information revelation, with probability $\gamma \in (0.5, 1]$; particularly:

- At $t = 2$, the central government observes a signal $\widetilde{\theta}_i \in \{H, L\}$, s.t. $Pr\left(\widetilde{\theta}_i = \theta_i\right) = \gamma$.

Thus, γ captures the *information accuracy of experiments*, with $\gamma = 1$ being full revelation (the baseline model). The condition $\gamma > 0.5$ implies that the signal is informative.

The central government's decision to continue the support, $s_2 = (1 - s_1)1\left\{\widetilde{\theta}_i = H\right\}$, now depends on the revealed signal $\widetilde{\theta}_i$ instead of the true type θ_i. As a result, even the H-type projects may lose the continuation of support due to a noisy signal.

This is reflected in the local government's decision rule:

$$a_L^*(s_i) = 1\{c_i \le c_L^*(s_1 \gamma)\}, \quad \text{for} \quad \theta_i = L;$$

$$a_H^*(s_i) = 1\{c_i \le c_H^*(s_1 \gamma)\}, \quad \text{for} \quad \theta_i = H;$$

where the two thresholds $c_L^*(s_1, \gamma) \equiv s_1 + (1 - \gamma)(1 - s_1)$ and $c_H^*(s_1, \gamma) \equiv s_1 + \gamma(1 - s_1)$.

The posterior of the H-type becomes:[25]

$$\sigma(s_1, \gamma) = Pr\{\theta_i = H | s_1, \gamma\} = \frac{p c_H^*(s_1, \gamma)}{p c_H^*(s_1, \gamma) + (1-p) c_L^*(s_1, \gamma)} \tag{2''}$$

which preserves the properties stated in Lemma 1 ($\forall \gamma > 0.5$):

- $\sigma(s_1, \gamma) > p$, $\forall s_1 < 1$; this is because $c_L^*(s_1, \gamma) < c_H^*(s_1, \gamma)$, $\forall\, \gamma > 0.5$, i.e., a higher fraction of H-type projects are proposed;
- $\sigma(s_1, \gamma)$ decreases in s_1, because $c_L^*(s_1, \gamma)/c_H^*(s_1, \gamma)$ increases in s_1, $\forall \gamma > 0.5$.

Thus, partial initial support remains to be an effective screening device.

The central government's *ex-ante* benefit, the previous Eq. (3), now becomes:

$$\text{E}\pi^*(s_1) = \sigma(s_1 \gamma)\{v_H[s_1 + \beta\gamma(1 - s_1)] + E\} + (1 - \sigma(s_1 \gamma))v_L[s_1 + \beta(1 - \gamma)(1 - s_1)].$$

[24] H-type projects are still always proposed, since they are now associated with even higher payoffs (α_H, $R \ge 0$).

[25] Here we assume uniform distribution of costs, $c_i \sim U[0, 1]$, for simplicity.

Equilibrium characterization (Proposition 1) holds accordingly.

Finally, it is straightforward to verify that $E\pi^*(s_1)$ still has increasing differences in each pair$(-s_1,\beta)$, $(-s_1, v_L)$, and $(-s_1, E)$. As a result, the comparative statics w.r.t. β, $|v_L|$ and E (Proposition 2) remain.

6.3. Local government's time preference

The baseline model assumes no discount for the local government. Here we relax this assumption and let the local governments discount the future with factor $\widetilde{\beta} \in (0,1)$.

The local government's decision is updated as follows:

$$a_L^*(s_i) = 1\{c_i \leq s_1\}, \quad \text{for} \quad \theta_i = L$$

$$a_H^*(s_i) = 1\left\{c_i \leq c_H^*\left(s_1,\widetilde{\beta}\right)\right\}, \quad \text{for} \quad \theta_i = H$$

where the H-type's threshold $c_H^*\left(s_1,\widetilde{\beta}\right) \equiv s_1 + \widetilde{\beta}(1-s_1)$.

The posterior of the H-type becomes:[26]

$$\sigma\left(s_1,\widetilde{\beta}\right) = Pr\left\{\theta_i = H|s_1,\widetilde{\beta}\right\} = \frac{p\left(s_1 + \widetilde{\beta}(1-s_1)\right)}{p\left(s_1 + \widetilde{\beta}(1-s_1)\right) + (1-p)s_1}.$$

Again, we have the properties stated in Lemma 1:

- $\sigma\left(s_1,\widetilde{\beta}\right)\rangle p$, since $c_H^*\left(s_1,\widetilde{\beta}\right) = s_1 + \widetilde{\beta}(1-s_1)\rangle s_1$; and
- $\sigma\left(s_1,\widetilde{\beta}\right)$ decreases in s_1, because $s_1/c_H^*\left(s_1,\widetilde{\beta}\right)$ increases in s_1.

The central government's equilibrium payoff (Eq. 3) is updated accordingly

$$E\pi^*(s_1) = \sigma\left(s_1\widetilde{\beta}\right)\{v_H[s_1 + \beta(1-s_1)] + E\} + \left(1 - \sigma\left(s_1\widetilde{\beta}\right)\right)v_L s_1,$$

and equilibrium characterization (Proposition 1) continues to hold.

Again, the introduction of local government's discounting, $\widetilde{\beta}$, while complicates the formula, does not alter the increasing differences nature of $E\pi^*(s_1)$ in $(-s_1, \beta)$, $(-s_1, v_L)$, and $(-s_1, E)$. Therefore, the comparative statics results (Lemma 2 and Proposition 2) continue to hold.

6.4. A remark on the local government's cost distribution(s)

In the baseline model, we assume that both types of local governments share the same cost distribution. We argue that this is without loss of generality. Suppose the cost distribution is quality-specific: $G(c)$ for H-type projects, and $F(c)$ for H-type projects, both on $[0,1]$.

Recall that H-type projects are always proposed (Lemma 1). Therefore, the posterior of H-type projects $\sigma(s_1) = Pr\{\theta_i = H|s_1\} = \frac{p}{p+(1-p)F(s_1)}$ is independent of $G(c)$, and so does the central and local governments' equilibrium payoffs $E\pi^*(s_1)$ and $u_i(s_1, s_2^*(\bullet);\theta_i)$.

Consequently, all the results (Lemmas 1, 2 and Propositions 1, 2) do not depend on $G(c)$ and remain the same as in the baseline case.

6.5. A remark on the central government's costs

In our model, the central government's cost function $C(\cdot)$ depends on n, the number of approved projects. Actually, our setup readily incorporates more general cost settings, upon proper reinterpretation.

In particular, let us divide the central government's cost on each approved project into two parts: a "fixed cost" that occurs once a

[26] Again for simplicity we assume uniform distribution of costs, $c_i \sim U[0,1]$.

project is approved, and "follow-up costs" that may depend on the (discounted total) support as well as the project's quality.

Our cost function $C(n)$ directly captures the "fixed cost" part, which increases when more projects are approved.

On the other hand, the project-specific "follow-up costs" are incorporated into the payoff relevant terms v_H and v_L, recall in Eq. (2):

$$\pi_i(s_1, s_2(\cdot);\theta_i) = v_{\theta_i} \cdot [s_1 + \beta s_2(\theta_i)] + E \cdot 1\{\theta_i = H\},$$

where v_{θ_i} can be viewed as $V_{\theta_i} - c_{\theta_i}$ such that V_{θ_i} is the central government's revenue (or welfare gain) from a project and c_{θ_i} is the project's (unit) follow-up cost. Notice that

- c_{θ_i} can be quality-specific;
- The total follow-up cost is proportional to $[s_1 + \beta s_2(\theta_i)]$, that is, the total (discounted) support of the project.

In other words, our specification of the cost function does apply to a wide range of cases and our key results remain.

7. Concluding remarks

In this paper we propose a theory of experimental zones that combines political centralization and local government's local knowledge: reform proposals are raised bottom-up rather than top-down, local governments are better informed about the project qualities, while central government can control the *reform speed* (defined as the initial support level in each experimental zone) and *scale* (the total number of experimental zones). Our rationale for the success of setting experimental zones is that providing supports gradually over time rather than all-at-once helps to screen the project quality.

Although this paper is mostly theoretical, as our comparative statics analysis implies, our results also generate hypotheses that can be tested by future studies. For instance, we predict that central government's discount factor β would have different impact on the support given to each project in its initial stage (s_1) and the equilibrium number of projects that is allowed (n). Potentially, one could use the number of conflicts on certain issue as a measure of urgency of the reform project (which could then be interpreted as central government's time preference on this issue).

More importantly, we generate very different empirical implications from the previous theories of experimental zones. As our discussion on a benchmark case in which there is no information asymmetry between central and local governments shows, while the initial support level *decreases* with the externality of the project in our model, it is independent with the externality when there is no screening mechanism at work. One can then examine empirically, how does a project's externality, which could vary across projects of different kinds, affect the initial support that is provided by central government.

Appendix I: Omitted proofs

We will apply the techniques of monotone comparative statics (e.g. Milgrom & Shannon, 1994). To do so, we first introduce some useful definition and lemma.

Definition A1. (Increase difference) *A function $F : X \times T \to \mathbb{R}$ has increasing difference (ID) in (x, t), if all $x, x' \in X$ and $t, t' \in T$ such that $x > x'$ and $t > t'$, $F(x', t') - F(x, t') \geq F(x', t) - F(x, t)$.*[27]

Definition A2. (Set-order) *A set $S \subsetneqq \mathbb{R}$ is bigger than $T \subsetneqq \mathbb{R}$, denoted $S \geq_S T$, if for every $x \in S$ and $y \in T$, $y \geq x$ implies $y \in S$ and $x \in T$.*[28]

Lemma A1. (Topkis Theorem) $F : X \times T \to \mathbb{R}$ has increase difference in (x, t), then $x^*(t)$ increases in set-order. Here $x^*(t) = argmax_x F(x, t)$.

Proof of Lemma A1. Consider $t', t \in T$ s. t. $t' > t$, for any $x \in x^*(t)$, $x' \in x^*(t')$ s.t. $x > x'$ (the case $x' = x$ is trivial). By contradiction, suppose $x' \notin x^*(t)$ (*). By definition of $x^*(\bullet)$ and (*), we have $F(x', t') \geq F(x, t')$ and $F(x, t) > F(x', t)$; and thus $F(x', t') - F(x, t') \geq 0 > F(x', t) - F(x, t)$, i.e. $F(x', t') - F(x', t) > F(x, t') - F(x, t)$. This contradicts to the fact that F has increasing difference in (x, t). □

Now we are prepared to prove the comparative statics results presented in the main text:

Proof of Proposition 1. The existence of solution is immediate: for 2), notice $E\pi^*(s_1^*) \geq E\pi^*(0) = \beta v_H + E > 0$ and thus the existence of $n^* > 0$ follows the regularity conditions of cost function $C(\bullet)$; for 3), s_1^* exists since we are maximizing a continuous function over a compact set. □

[27] When is twice continuous differentiable, then ID is equivalent to $\frac{\partial^2 F}{\partial x \partial t} \geq 0$.

[28] Note we only need this when there might be multiple equilibrium values.

Proof of Lemma 2. Recall $E\pi^*(s_1) = \sigma(s_1) \bullet \{v_H[s_1 + \beta(1 - s_1)] + E\} + (1 - \sigma(s_1)) \bullet v_L s_1$. And notice it is equivalent to show $(s_1, \bullet)$ has decreasing difference (DD). For $s_1' > s_1$, $\beta' > \beta$, $E' > E$ and $|v_L'| > |v_L|$ (i.e. $v_L' < v_L$ since v_L is always negative):

1)$E\pi^*(s_1', \beta) - E\pi^*(s_1, \beta) = \beta \bullet v_H[\sigma(s_1')(1 - s_1') - \sigma(s_1)(1 - s_1)] < \beta' \bullet v_H[\sigma(s_1')(1 - s_1') - \sigma(s_1)(1 - s_1)] = E\pi^*(s_1', \beta') - E\pi^*(s_1, \beta')$, here the inequality holds since both $\sigma(s_1)$ and $(1 - s_1)$ are positive and decreasing in s_1 (and thus $\sigma(s_1')(1 - s_1') - \sigma(s_1)(1 - s_1)<0$);

2) Since $\sigma(s_1') - \sigma(s_1) < 0$, $E\pi^*(s_1', E) - E\pi^*(s_1, E) = E \bullet [\sigma(s_1') - \sigma(s_1)] < E' \bullet [\sigma(s_1') - \sigma(s_1)] = E\pi^*(s_1', E') - E\pi^*(s_1, E')$;

3) $v_L', v_L < 0$, thus $E\pi^*(s_1', |v_L|) - E\pi^*(s_1, |v_L|) = -|v_L| \bullet [(1 - \sigma(s_1'))s_1' - (1 - \sigma(s_1))s_1] < -|v_L'| \bullet [(1 - \sigma(s_1'))s_1' - (1 - \sigma(s_1))s_1] = E\pi^*(s_1', |v_L'|) - E\pi^*(s_1, |v_L'|)$. □

Proof of Proposition 2. 1) is from lemma 1 by applying lemma 2 (Topkis).

Before showing 2) we first discuss the results of $E\pi^*(s_1^*)$ in 3). We illustrate the case $\beta' > \beta$, and the results for E and $|v_L|$ can be shown in exactly the same way. Recall $E\pi^*(s_1, \beta) = \sigma(s_1) \bullet \{v_H[s_1 + \beta(1 - s_1)] + E\} + (1 - \sigma(s_1)) \bullet v_L s_1$ is continuous, $[0, 1]$ is compact, and $\frac{\partial}{\partial\beta} E\pi^*(s_1, \beta) = \sigma(s_1)(1 - s_1)v_H \geq 0$ always exists (with inequality for all $s_1<1$). Then by Envelope Theorem, $E\pi^*(s_1(\beta'), \beta') - E\pi^*(s_1(\beta), \beta) = \int_\beta^{\beta'} [\sigma(s_1(b))(1 - s_1(b))v_H]db > 0$, for any selection $s_1(b) \in s_1^*(b)$. Thus $E\pi^*(s_1^*)$ strictly increases in β.

Now back to 2). FOC w.r.t. n^*: $E\pi^*(s_1^*) = C'(n^*)$, and since $C'(\bullet) > 0$ we have a larger n^* when $E\pi^*(s_1^*)$ is larger. Then applying generalized Envelope Theorem implies $E\Pi^*(t') - E\Pi^*(t) = \int_t^{t'} E\pi^*(s_1^*, \alpha)d\alpha > 0$, here α represents the exogenous parameter β, E, or $|v_L|$, and recall $E\pi^*(s_1^*, \alpha) \geq E\pi^*(0, \alpha) > 0$. □

A remark on generalized functional form

The results and discussions in this paper do not rely much on the special functional forms. Here we consider a more generalized functional form:

$$E\pi^*(s_1) = \sigma(s_1)[v_1(s_1; H) + \beta v_2(1 - s_1; H) + E] + (1 - \sigma(s_1))v_1(s_1; L)$$

with following properties:

1) $\sigma(s_1) = \sigma(H|y; s_1)$, is continuous, and decreasing in s_1;
2) $v_1(\bullet; H), v_2(\bullet; H) \geq 0$ are continuous and increasing in the first component;
3) $v_1(s_1; L)$, is continuous.

Proposition A1. *There exists an equilibrium. When β and/or E increase, s_1^* decreases in set order, both $E\pi^*(s_1^*)$ and $E\Pi^*(s_1^*)$ strictly decrease, and n^* strictly decreases.*

Proof. For $s_1' > s_1$, $\beta' > \beta$, and $E' > E$: $E\pi^*(s_1'; \beta) - E\pi^*(s_1; \beta) = \beta[\sigma(s_1')v_2(1 - s_1'; H) - \sigma(s_1)v_2(1 - s_1; H)] \leq 0$, since $\sigma(s_1') \leq \sigma(s_1)$, $v_2(1 - s_1; H) \leq v_2(1 - s_1'; H)$ and all these terms are non-negative.

Therefore $E\pi^*(s_1'; \beta) - E\pi^*(s_1; \beta) > E\pi^*(s_1'; \beta') - E\pi^*(s_1; \beta')$. Also, $E\pi^*(s_1', E) - E\pi^*(s_1, E) = E[\sigma(s_1') - \sigma(s_1)] < E'[\sigma(s_1') - \sigma(s_1)] = E\pi^*(s_1', E') - E\pi^*(s_1, E')$. Thus $E\pi^*$ has increasing difference in $(-s_1, \beta)$ and in $(-s_1, E)$. Then following the arguments in proof of Proposition 2 will provide us the results. □

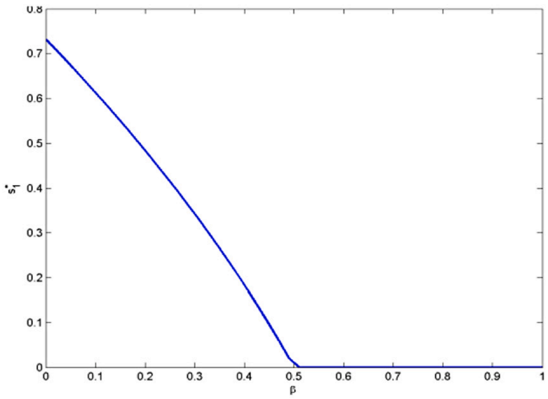
Appendix II: An illustrating example of the equilibrium

Example: *Consider $F(c_L)\sim$Uniform[0,1], $E = 0$, and $C(n) = 0.5n^2$. We have $s_1^* = 0$ when $\beta \in \left[p\left(1 - \frac{v_L}{v_H}\right), 1\right)$, and $s_1^* = \frac{1}{1-p}\left\{\sqrt{\frac{p[(\beta-p)v_H+pv_L]}{v_L}} - p\right\} \in (0,1)$ otherwise.*[29]

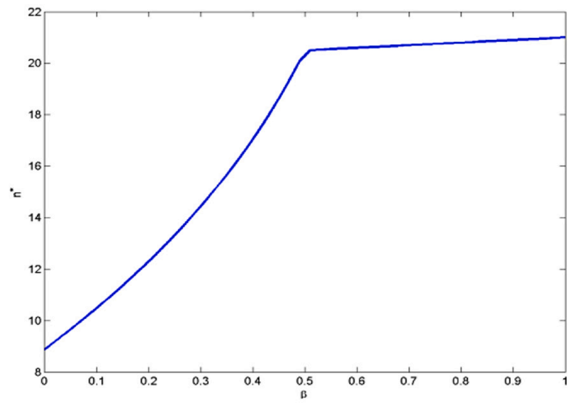
We remark that $s_1^* = 0$ shall be interpreted as implementing an experiment at a tiny (minimal) amount so that quality of the project can still be revealed.

As illustrated in Fig. 3, as the central government becomes more patient, it tends to approve more proposals, but at smaller initial levels. With large enough β, central government chooses $s_1^* = 0$. Otherwise, it chooses an interior $s_1^* > 0$ so that some L-type projects are proposed. Easy to see that $s_1^{*\prime}(\beta) \leq 0$, $n^{*\prime}(\beta) > 0$ and $E\Pi^{*\prime}(\beta) > 0$.

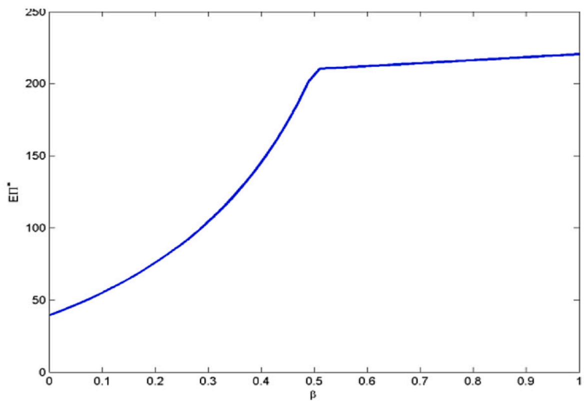
[29] Here we assume $p\left(1 - \frac{v_L}{v_H}\right)\langle 1$. Otherwise, the first case does not appear.



(a) eq. speed (initial support level)



(b) eq. scale (# of projects approved)



(c) eq. payoff of central government

Fig. 3. Comparative statics w.r.t. time preference (β).
Note: functional forms introduced in Example 1, with $p = 0.5$, $\nu_L = -10$, $\nu_H = 20$; $\beta \in (0,1)$.

Appendix III: Comparative statics results on the terms considered in Section 6

Proposition A2. *Consider the extensions presented in* 6.1—6.3, *respectively*.

The central government's benefits, $E\pi^*(s_1^*)$ and $E\Pi^*(n^*, s_1^*)$, as well as the reform scale, measured by the equilibrium number of projects n^*, all:

(*for parameters in extension* 6.1)

- *decrease the intrinsic payoff of L-type projects*, α_L;
- *increase in the central government's ability of punishment*, P;
- *hold constant in the intrinsic payoff of the H-type*, α_H, *and the reward ability*, R;

(*for parameters in extension* 6.2)

- *increase in the information accuracy*, γ;

(*for parameters in extension* 6.3)

increase in the local government's discount factor, $\widetilde{\beta}$.

Proof. According to Envelope Theorem, it suffices to examine the direct impacts (partial derivative) of each term on the benefit, $E\pi^*(s_1^*)$. The directions follow from simple calculations. □

The results above tell us that, for instance, when we reduce the payoff of corruption (corresponds to a lower α_L), establish better punishment devices (a larger P), increase information accuracy of the experiments (a higher γ), or when local governments become more patient (a higher $\widetilde{\beta}$), there is an enlarged reform scale.

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