北京大学中国经济研究中心
China Center for Economic Research
讨论稿系列
Working Paper Series

E2024005 2024-04-15

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Political Stake and Policy Experimentation

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April 15, 2024

Abstract

Policy experimentation is an increasingly common practice for institutional reforms. Meanwhile, policy makers may be politically motivated to bias the information revealed by experiments. This paper develops a model of Bayesian persuasion to study how political stake shapes policy experimentation. The model shows that the optimal experiment almost never elicits information perfectly when the policy involves some political stake. The optimal experiment is conducive to type-I error (over-reform) when the stake is large and type-II error (under-reform) when the stakes are small. Experimentation is most likely to enhance the probability of reform when the political stake is distributed within an intermediate range. The paper examines this argument empirically against case studies in Uganda, Kenya, the Soviet Union, and Vietnam, as well as through an investigation of the reform of the Household Responsibility System in Chinese counties in the 1980s.

1 Introduction

Policy reform is a risky business with varying costs and benefits. Reformers face the central task of persuading stakeholders by providing relevant information on the costs and benefits associated with new policies. For that reason, academics and policy makers have widely advocated randomized controlled trials as the gold standard for policy experimentation (Duflo, 2020). Following this reasoning, scholars have argued that nonrandomly designed experimentation tends to compromise the efficacy of reform. A recent paper by Wang and Yang (2021) empirically examines policy experiments in China since 1980. It reports that experiments were often biased in favor of the central government's agenda due to positive sample selection and strategic accommodation by local officials.

At the same time, the implementation of a new policy agenda is often associated with a reshuffling of personnel and political power among different groups (Hellman, 1998). Hence, the design of policy experimentation reflects not only the rationale of eliciting information, but also the political motives of policy makers. A political economy theory of policy experimentation must consider the following questions. How do the political stake of a reform affects the incentive to initiate the reform? Under what conditions is perfectly informative experimentation optimal? What happens to the efficacy of experimentation when rival political forces have the power to block reform initiatives?

This paper develops a game-theoretical model of Bayesian persuasion to study how the political stake of a reform shapes the strategic interactions in policy experimentation and reform dynamics. The model examines an environment in which an incumbent (reformer) and an opposition faction jointly decide whether to implement a new policy. The incumbent has the power to initiate the policy and is responsible for designing an experiment to elicit information about the reform's potential payoff. The opposition faction has the power to veto or approve the new

policy upon observing the outcome of the experiment. The incumbent and the opposition faction derive a common value of the economic payoff, but they diverge on the political stakes of the reform. To alleviate resistance to the reform, the incumbent can design an experiment that helps to elicit information about the economic payoff of the policy. The incumbent can manipulate the experiment to generate "false positives" in the sense that outcomes will be better at the experimental stage than when the reform is universally implemented.

The model demonstrates that the political stakes play a crucial role in driving the odds of successful experimentation. In contrast to the conventional wisdom that politicization of policy making will necessarily decrease the likelihood of reform, the model suggests that there is a nonmonotonic relationship between the political stakes and the probability of reform when the reformer can use experimentation to persuade. When the political stakes are relatively small, the probability of a false positive result (over-reform) increases with the level of political stakes. By contrast, when the political stakes are relatively large, the probability that the reform will be implemented decreases with the level of the political stakes, and the experimentation eventually produces false negative results when the political stakes are sufficiently large. Interestingly, an experiment that perfectly matches the fundamental returns of the reform policy is almost never optimal when the policy involves some political stake.

In turn, the combination of the political stakes and the expectation of the reform's payoff (relative to the status quo) leads to the different equilibrium cases of reform stagnation, experimentation (in which the reform is implemented with a probability), and big bang reform. The model suggests that reform through experimentation is most likely when the political stake is distributed within an intermediate range. When the political stake is too high (low) relative to the economic payoff under the status quo, the incumbent is unable (or unwilling) to initiate a reform that is likely to be implemented. Finally, when the political stake is in the inter-

mediate range, the equilibrium is associated with under-reform (false negatives) for relatively large political stakes and over-reform (false positives) or big bang reform for relatively small political stakes. The case studies in Uganda, Kenya, the Soviet Union, and Vietnam are largely consistent with the theoretical insights of the model.

The paper examines the merits of the model in the context of the implementation of the Household Responsibility System (HRS) in China in the 1980s. The HRS granted peasants economic rights to manage agricultural production and was an issue of high political stake due to its potential challenge to state ownership of land. The policy stances toward the HRS were sharply divided within the Communist Party of China. The Party's central leadership solved the debate by conducting policy experimentation at smaller scales before the HRS was implemented nationwide. Empirical analysis of county-level data on the implementation of the HRS obtains two results that are consistent with the theory. First, the overall political stakes, as measured by the relative sizes of the factions in power, decreased in 1978-87, indicating that moderation of the political stakes may have helped to induce the reform toward the HRS. Second, consistent with the model, the relationship between the level of the political stakes and the probability of being a local experimenter exhibits an inverted U-shape.

The remainder of the paper proceeds as follows. Section 2 discusses the paper's relationship to the literature. Section 3 presents the setup and analytical results of the model. Section 4 discusses the equilibrium cases. Section 5 provides case studies in line with the equilibrium cases. Section 6 employs county-level data from the implementation of the HRS in China to examine the empirical implications of the model. Section 7 concludes.

2 Relation to Literature

This paper speaks to a growing literature on the political economy of policy experimentation. Most existing formal models of policy experimentation are concerned with information problems in the context of federalism with electoral motives (Cai, Treisman et al., 2009; Cheng and Li, 2019). Callander and Harstad (2015) present a formal model to study the interplay between experimentation and policy diffusion. They show that experimentation enhances the efficiency of policy making when the central government uses tournament competitions to incentivize localities. Among a few papers examining experimentation in authoritarian regimes, Xie and Xie (2017) focus on strategic purpose of advancing the standing of rival factions in the contest for political power. Echoing the theoretical contributions, empirical studies on policy experimentation in the Chinese context confirm that a political-economic mechanism may have biased the adoption and design of experimentation in policy making (Heilmann, 2008; Wang and Yang, 2021).

Comparing with Callander and Harstad (2015) and Xie and Xie (2017), the formal model presented in this paper provides a new theoretical perspective on information design for understanding how experimentation works in politically motivated policy making. Unlike Xie and Xie (2017), who assume that competing factions have certain, but uncommon, knowledge about the policy's payoff, our model shows that the political stakes of a reform have a significant impact on the design of policy experimentation even when the incumbent and the opposition faction share a common prior about the reform. Moreover, this paper is connected to a strand of theoretical papers on how the political motives of bureaucratic agents may enhance policy efficacy (Besley and Ghatak, 2005; Prendergast, 2007). The paper reconciles this literature with recent empirical research on policy evaluation by providing a micro-foundation for strategic information design. The model shows that biased experimentation may be desirable as it is intended not merely as a

mechanism for eliciting information, but a program of political persuasion. Paradoxically, experimentation that elicits information perfectly is almost never optimal for politicians.

The literature on the political economy of reform has reached an overall consensus that divided economic interests pose an obstacle to reforms in policy areas such as tax cuts, trade opening, and deregulation (Brainerd, 1998; Frye and Mansfield, 2003; Tucker, Pacek and Berinsky, 2002). Previous literature has also attributed stagnation of reform to rivalry between political powers (Acemoglu, 2003; Dixit and Londregan, 1995). Alesina and Drazen (1991) formalize this idea in a war-of-attribution game, suggesting that politically divided parties may strategically hold onto the status quo to avoid bearing the cost of reform. Acemoglu and Robinson (2006) demonstrate a nonmonotonic relationship between political competition and the likelihood of reform, showing that the obstacle to reform is the highest when the incumbent faces an intermediate level of challenge. Our theoretical model contributes to this literature by demonstrating the use of policy experimentation in moderating the political stakes of reforms.

Finally, this paper sheds light on the interplay between political institutions and the dynamics of reform. It has been suggested that political centralization serves as an institutional foundation for incremental reforms in China (Blanchard and Shleifer, 2001; Goldstein, 1995; Rawski, 1995). By contrast, the structural reform in Russia in the 1990s adopted a big bang approach and was associated with greater political transformation (Shleifer and Treisman, 2001). The theoretical model presented in this paper provides a novel mechanism for information acquisition to explain the variation in the trajectory of reform (Gallagher, 2002; Gilley, 2008; Jain, Majumdar and Mukand, 2014; Malesky, 2008; Yang, 2006).

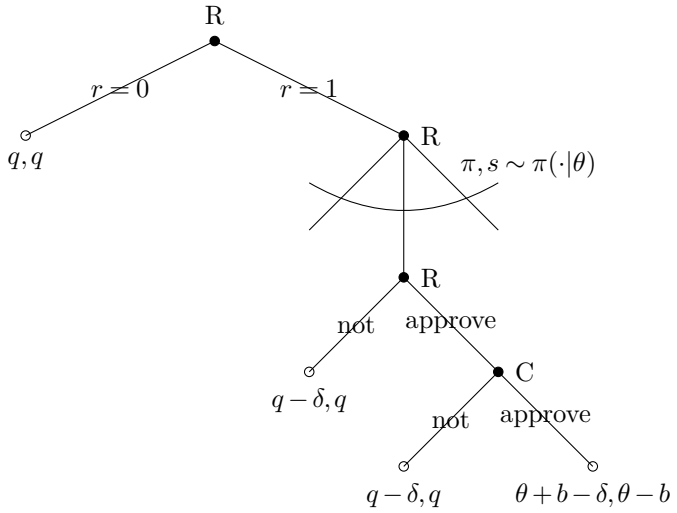
3 A Formal Model

3.1 Setup

The players are two political factions, R and C, representing the reform-leaning and conservative factions, respectively, in the ruling political coalition. Without any loss of generality, R is the incumbent player and chooses whether to *propose* a reform, $r \in \{0,1\}$. The status quo yields an economic payoff $q > 0$, which is shared by R and C. If the reform were implemented, it would change the economy to an unknown state $\theta \in \Theta := \mathbb{R}_+$, drawn from a distribution F that has full-support on Θ and a log-concave density f. R bears disutility $\delta \in (0, E(\theta))$ for initiating the reform, and δ includes both a tangible administrative cost and an opportunity cost of diverting resources and attention from otherwise desirable projects. The political coalition's decision-making is consensual: a proposed reform is *implemented*, $m \in \{0,1\}$, if and only if it is *approved* by both R and C. The status quo is preserved if R chooses not to propose any reform, or if R proposes a reform yet fails to obtain approval from C. This setting is relevant for many political contexts in which different parties and factions have veto power over crucial decisions. A reform is *efficient* if it would improve the economy relative to the status quo, $\theta \geq q$; and it is *inefficient* if it would make the economy worse than the status quo, $\theta < q$. The two factions would make an *over-reform* mistake (type-I error) by implementing an inefficient reform and an *under-reform* mistake (type-II error) by failing to implement an efficient reform.

After proposing a reform, R employs experimentation to acquire information about its effect θ. Formally, R designs and conducts an experiment π which consists of a set of observable outcomes S_π and a mapping $\pi : \Theta \to \Delta(S_\pi)$. Conditional on θ, π stochastically generates an outcome $s \sim \pi(\cdot|\theta) \in \Delta(S_\pi)$. After observing the outcome s, R and C choose whether to approve the reform. The reform is implemented, $m = 1$, if both R and C approve it.

Figure 1: Timing



R and C have both economic and political concerns with regard to reforms. On the one hand, they share *common* interests in promoting the economy, receiving the payoff of q if the status quo persists and the payoff θ if a reform is implemented. On the other hand, the two factions have *competing* political interests. Proposing and implementing a reform provides R with the opportunity to accumulate political capital, gaining advantage against C. The asymmetric political stakes take various forms, such as electoral benefits, control of personnel appointments, and agenda-setting power in future decision-making. We model the political stake in a reduced-form fashion: R gets an additional political payoff of $b \geq 0$ at the expense of C by proposing and implementing a reform. As R's political gain and, equivalently, C's political loss, b measures the *political stake* a reform entails. A reform is *apolitical* if it entails no political stake, $b = 0$. Figure 1 presents the sequence of move and payoffs of R and C. The solution concept is *perfect Bayesian equilibrium* (henceforth equilibrium).

3.2 Experimentation Characterization

We now characterize an essential feature of the experiment, π. In principle, π may take various forms. For any π and an outcome signal $s \in S_\pi$ generated by π,

R and C update their belief about the effect of the reform θ to

$$E(\theta|s,\pi) = \frac{\int_\Theta \theta\pi(s|\theta)dF(\theta)}{\int_\Theta \pi(s|\theta)dF(\theta)}.$$

In turn, C would approve the reform only if

$$E(\theta|s,\pi) - b \geq q.$$

R would proceed to approve the reform if the above condition holds, because

$$E(\theta|s,\pi) + b \geq E(\theta|s,\pi) - b \geq q.$$

To put R and C's preferences together, the reform would be implemented if and only if the experiment π generates an outcome $s \in S_\pi$ such that $E(\theta|s,\pi) - b \geq q$, so that

$$m = m^*_\pi(s) := \begin{cases} 1, & E(\theta|s,\pi) - b \geq q \\ 0, & E(\theta|s,\pi) - b < q \end{cases}. \tag{1}$$

Given the effect of the reform θ, an experiment π would lead to implementation of the reform with probability

$$\Pr(m = 1|\theta,\pi) = p_\pi(\theta) := \int_{S_\pi} m^*_\pi(s)\pi(s|\theta)ds. \tag{2}$$

We refer to function $p_\pi : \Theta \to [0,1]$ as the *conditional probability of implementation* induced by experiment π. Each experiment induces a conditional probability of implementation. Moreover, given that R has proposed a reform, R's expected payoff by setting an experiment π is

$$\int_\Theta \left(p_\pi(\theta)(\theta + b) + (1 - p_\pi(\theta))\, q\right) dF(\theta) - \delta = \int_\Theta p_\pi(\theta)\left(\theta - (q - b)\right) dF(\theta) + q - \delta,$$

which depends on π only through the induced conditional probability of implementation p_π. This implies that R is indifferent between two experiments π_1 and π_2 if they induce the same conditional probability of implementation. Hence, instead of specifying the exact form of π, it suffices to analyze R's optimization problem in choosing a best *feasible* conditional probability of implementation, defined and characterized as below.

Definition 1. *A conditional probability of implementation $p : \Theta \to [0,1]$ is feasible if there exists an experiment π that induces p, that is, $p(\theta) = p_\pi(\theta)$ holds for all $\theta \in \Theta$. The set of all feasible conditional probabilities of implementation is $\mathcal{P}$.*

Lemma 1. *A conditional probability of implementation $p : \Theta \to [0,1]$ is feasible, $p \in \mathcal{P}$, if and only if*

$$\int_\Theta p(\theta)\,(\theta - (q+b))\,dF(\theta) \geq 0, \quad \textit{if} \quad \int_\Theta p(\theta)dF(\theta) > 0 \tag{3}$$

$$\int_\Theta (1-p(\theta))\,(\theta - (q+b))\,dF(\theta) < 0, \quad \textit{if} \quad \int_\Theta p(\theta)dF(\theta) < 1. \tag{4}$$

Conditions (3) and (4) are referred to as the *feasibility* constraints. We relegate the proof of Lemma 1 to the appendix. The intuition of the result is that conditional on implementation, C must find the reform no worse in expectation than keeping the status quo. Indeed, under a feasible conditional probability of implementation $p \in \mathcal{P}$, whether the reform is implemented, m, is drawn according to

$$\Pr(m = 1|\theta, p) = p(\theta)$$

conditional on the effect of the reform θ. Hence, (3) holds if and only if C's expected payoff of approving the reform conditional on $m = 1$ is no worse than the payoff from keeping the status quo, that is,

$$E(\theta|m = 1, p) - q \geq b.$$

Similarly, C must expect the reform to generate a worse payoff than the status quo if the reform is not approved. Formally, (4) holds if and only if C's expected payoff of approving the reform conditional on $m = 0$ is worse than the payoff from keeping the status quo, that is,

$$E(\theta|m = 0, p) - q < b.$$

3.3 When is the Experimentation Perfect?

We now turn to analyzing important properties of experimentation. Following Definition 1, the effect of an experiment can be fully characterized by the conditional probability of implementation p_π it induces. Specifically, we define over-reform and under-reform induced by any given experiment as follows.

An experiment π *produces over-reform* if

$$\int_0^q p_\pi(\theta) dF(\theta) > 0, \tag{5}$$

so that the two factions may be misled to implement an inefficient reform that would make the economy worse than the status quo. An experiment π *produces under-reform* if

$$\int_q^\infty (1 - p_\pi(\theta))\, dF(\theta) > 0, \tag{6}$$

so that the two factions may be misled to fail to implement an efficient reform that would improve the economy relative to the status quo. An experiment π is *perfect* if it produces neither over-reform nor under-reform.

Clearly, π is perfect if and only if

$$p_\pi(\theta) = \begin{cases} 1, & \theta \geq q \\ 0, & \theta < q \end{cases}. \tag{7}$$

Hence, there could be multiple perfect experiments, but they all induce the same conditional probability of implementation. Consider a special experiment π such that $S = \Theta$ and $\pi(s = \theta|\theta) = 1$ holds for all θ. This experiment is *fully informative*: its outcome s always coincides with the true effect of the reform θ. However, the fully informative experiment needs not be perfect. Under the fully informative experiment, $E(\theta|s, \pi) = s$ and

$$m_\pi^*(s) = \begin{cases} 1, & s - b \geq q \\ 0, & s - b < q \end{cases},$$

so that

$$p_\pi(\theta) = \begin{cases} 1, & \theta \geq q + b \\ 0, & \theta < q + b \end{cases}.$$

Hence, the perfectly informative experiment produces under-reform as long as the reform entails a non-trivial political stake $b > 0$, where F is the distribution function corresponding to f. When $q \leq \theta < q + b$, the reform is efficient, but its payoff is not large enough to justify C's political loss. So C will not approve the reform. The fully informative experiment is perfect only if the reform entails no political stake at all. This result implies that experimentation designs that strictly follow the RCT rules may be appealing only under narrow circumstances in which the reform is politically trivial and incurs no internal political struggle.

3.4 Reformer's Optimal Experimentation

As Lemma 1 makes it clear, one only needs to focus on the feasible conditional probability of implementation p_π to establish all the key properties of the optimal

experiment. R's problem of optimization can be written as

$$\max_{p\in\mathcal{P}} \quad \int_{\Theta} p(\theta)\,(\theta-(q-b))\,dF(\theta)+q-\delta \tag{8}$$

The fundamental features of the optimal experimentation as preferred by the reformer are characterized by the following proposition.

Proposition 1. *In any equilibrium, R chooses an experiment π that induces the conditional probability of implementation*

$$p_\pi(\theta)=p^*(\theta):=\begin{cases}1, & \theta\geq k^*(b,q)\\ 0, & \theta<k^*(b,q)\end{cases},$$

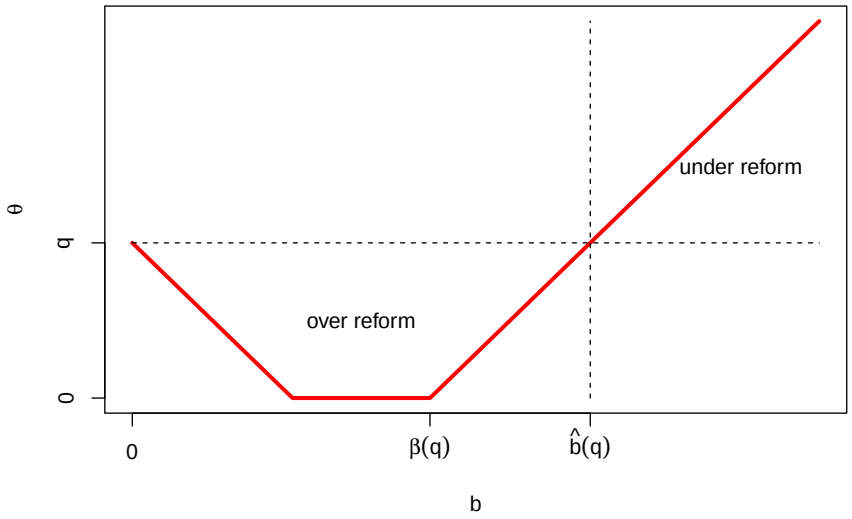
where

$$k^*(b,q):=\begin{cases}\max\{q-b,0\}, & b<b^*(q)\\ \min\{k\in\mathbb{R}_+:\ E(\theta|\theta\geq k)\geq q+b\}, & b\geq b^*(q)\end{cases}, \tag{9}$$

and $b^*(q)>0$.

There could be multiple optimal experiments R can design and conduct, but according to Proposition 1, these optimal experiments would induce a unique conditional probability of implementation. Under those experiments, the reform would be implemented if its effect were sufficiently good, so that $\theta\geq k^*(b,q)$; and it would not be implemented if the effect were not good enough, so that $\theta<k^*(b,q)$. Moreover, the threshold $k^*(b,q)$ is not monotone in the political stakes the reform entails. It is strictly decreasing in the political stake b when b is sufficiently small, $b<b^*(q)$, and increasing if b is sufficiently large, so that $b\geq b^*(q)$. Figure 2 presents the threshold functions and possible scenarios under the optimal experimentation of R.

Figure 2: Equilibrium cases



3.5 Over-reform and Under-reform

The feasibility constraint requires C to be willing to approve the reform. With a smaller political stake, it would be more likely that the feasibility constraint would hold. When b is sufficiently small, so that $b < b^*(q)$, the feasibility constraint is not binding for R's optimization problem (8). As a result, R will choose experiments under which the reform would be implemented if and only if R's aggregate payoff from the reform exceeds the status quo payoff, that is, if and only if $\theta \geq \max\{q-b, 0\}$. Hence, in this case,

$$k^*(b,q) = \max\{q-b, 0\}.$$

Such an experiment entails over-reform unless $b = 0$. Specifically, when the reform involves some, but not too unbearable, political stake, $(b \in (0, \hat{b}(q))$, and when the reform is inefficient but sufficient to yield an additional benefit for R, $\max\{q-b, 0\} \leq \theta < q$, R's optimal experiment will lead to over-reform. In this sce-

nario, reform makes the economy worse off compared with the status quo, but R obtains a political advantage from implementing the reform. This result provides a rational explanation for Wang and Yang (2021)'s empirical finding in the Chinese context that policies based on successful local experiments often turn out to yield inferior outcomes when they are implemented at the national level.

By contrast, when the reform entails a sufficiently large political stake, $b \geq b^*(q)$, the feasibility constraint would be so demanding that it would be binding for R's optimization problem (8). R's primary concern is to design a credible experiment such that C will approve when the reform is indeed worthwhile economically even given its political cost to C. By the definition of $k^*(b,q)$ in (9), this is the smallest threshold for θ such that C's belief about θ conditional on implementation, $E(\theta|\theta \geq k)$, is good enough to get C's approval, $E(\theta|\theta \geq k) \geq q+b$. In fact, because the distribution of θ is continuous, the above inequality must hold with equality at $k = k^*(b,q)$, which is equivalent to the binding feasibility constraint,

$$\int_k^\infty (\theta - (q+b))\, dF(\theta) = 0.$$

Proposition 2 summarizes the above discussion and provides the comparative statics of the probabilities of over-reform and under-reform.

Proposition 2. *Let*

$$\hat{b}(q) := E(\theta|\theta \geq q) - q, \tag{10}$$

then $\hat{b}(q) > b^*(q)$. *In any equilibrium, R chooses an experiment* π *that produces over reform if* $0 < b < \hat{b}(q)$, *produces under reform if* $b > \hat{b}(q)$, *and is perfect if* $b \in \left\{0, \hat{b}(q)\right\}$. *Moreover, if* $0 < b < \hat{b}(q)$, *the probability of over reform conditional*

on implementation,

$$\frac{F(q) - F\left(k^*(b,q)\right)}{1 - F\left(k^*(b,q)\right)},$$

is increasing in $b < b^*(q)$ *and decreasing in* $b \geq b^*(q)$*; and if* $b > \hat{b}(q)$*, the probability of under reform conditional on no implementation,*

$$\frac{F\left(k^*(b,q)\right) - F(q)}{F\left(k^*(b,q)\right)}$$

is strictly increasing in b*.*

Proposition 2 summarizes how the political stake distorts the collective decision on the reform. The probability of over-reform, however, is not always increasing in the level of political stake. When $b \geq b^*(q)$, a larger political stake would alleviate over reform. The reason is that when the reform entails a sufficiently large political stake, $b \geq b^*(q)$, the feasibility constraint starts to matter. Remember that the implementation of the reform needs to be approved by both players. Although a larger political stake would make the reform more attractive for R, it will simultaneously make C more reluctant to implement the reform due to C's political loss. Thus, for C to approve, R must conduct experiments that generate stronger evidence about the potential economic benefits of the reform, which necessarily would constrain over-reform.

Interestingly, when the reform entails the particular level of political stake $b = \hat{b}(q)$, R's political opportunism would be perfectly neutralized by C's need for evidence. As a result, R would optimally set a perfect experiment under which the reform would be implemented if and only if it is efficient and would improve the economy relative to the status quo. The case for a reform that entails the political stake of $b = \hat{b}(q)$ appears similar to the case for an apolitical reform with $b = 0$. Note that although these two cases have the same equilibrium conditional probability of implementation, the sets of R's optimal experiments are different. The fully

informative experiment, for instance, is optimal when $b = 0$ but it is not optimal when $b = 1$. But when $b = \hat{b}(q)$, the fully informative experiment is not perfect and therefore not optimal. An example of optimal experiment in the case of $b = \hat{b}(q)$ is one that fully discloses θ when $\theta < q$ and generates a single coarse outcome $s = 1$ when $\theta \geq q$.

With an overly large political stake $b > \hat{b}(q)$, C would need conclusive evidence about the economic gains the reform would bring about to compensate its painful political loss. To provide such evidence, R would have to run conservative experiments that produce under-reform. Given $b > \hat{b}(q)$, the larger the political stake is, the stronger would be the evidence that C would need to approve the reform, and consequently the more likely it would be that the two factions would make the mistake of under-reform.

4 Reform Stagnation and Big-push

It remains to analyze under what circumstance R would propose reform. By not proposing any reform, R obtains the status-quo payoff q. By proposing a reform and then running an optimal experiment characterized in Proposition 1, R expects to gain

$$\max_{p \in \mathcal{P}} \int_{\Theta} p(\theta) \left(\theta - (q - b)\right) dF(\theta) + q - \delta.$$

Therefore, R would propose a reform if and only if

$$v(b, q) := \max_{p \in \mathcal{P}} \int_{\Theta} p(\theta) \left(\theta - (q - b)\right) dF(\theta) = \int_{k^*(b,q)}^{\infty} \left(\theta - (q - b)\right) dF(\theta) \geq \delta, \qquad (11)$$

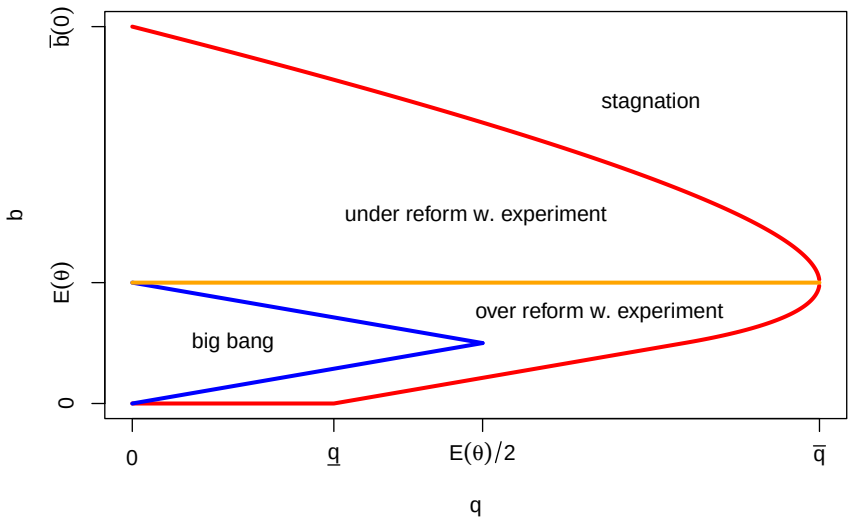
so that R's the aggregate gain both economically and politically, in addition to the status quo, justifies the opportunity cost of reform.

Proposition 3. *There are two uniquely defined thresholds for the status quo* $\underline{q} > E(\theta) - \delta$ *and* $\overline{q} > E(\theta) - \frac{\delta}{2}$ *such that* $\underline{q} < \overline{q}$ *with the following properties. First, if* $q > \overline{q}$*, R does not propose any reform regardless of its political stake b. Second, if* $q \leq \overline{q}$*, R proposes a reform if and only if it entails a political stake b such that*

$$\underline{b}(q) \leq b \leq \overline{b}(q),$$

where $0 \leq \underline{b}(q) \leq \hat{b}(q) \leq \overline{b}(q)$*,* $\underline{b}(q) > 0$ *is strictly increasing in q for all* $q > \underline{q}$ *and* $\underline{b}(q) = 0$ *for all* $q \leq \underline{q}$*, and* $\overline{b}(q)$ *is strictly decreasing in q and* $\underline{b}(\overline{q}) = \overline{b}(\overline{q}) = \hat{b}(q)$*.*

Figure 3: Equilibrium cases



Notes:

Proposition 3 provides the conditions under which R would propose a reform in equilibrium. When the status quo is sufficiently good, $q > \overline{q}$, reform is impossible because R would never propose a reform. In this case, the economy is in stagnation due to R's lack of incentive to initiate any reform.

By contrast, when the status quo is extremely poor, $q \leq \underline{q}$, R would propose a

reform as long as its political stake is sufficiently low, $b \leq \overline{b}(q)$. Because $v(0,q)$ is strictly decreasing in q, it would be profitable for R to propose an apolitical reform when the status quo is sufficiently bad, so that $q \leq \underline{q}$. In this case, R would propose a reform as long as its political stake is not too large, allowing a good chance to get the reform implemented.

Finally, when the status quo is neither too poor nor too good, so that $\underline{q} < q \leq \overline{q}$, R would initiate a reform if and only if its political stake is in the intermediate range, $\underline{b}(q) \leq b \leq \overline{b}(q)$. In this case, the potential economic benefit from a reform alone would not justify R's opportunity cost. Hence, R would not find proposing an apolitical reform profitable. Because the economic benefit alone is insufficient, R would require in addition a sufficiently good political benefit to be willing to propose a reform. In this case, R's political stake has subtle effects on the prospect of reform. On the one hand, an overly high political stake, $b > \overline{b}(q)$, would prevent reform from being proposed, leading to a *stagnation* of reform. On the other hand, so long as the status quo is not extremely poor, some political stake, $b \geq \underline{b}(q)$, is necessary to make reform possible. By contrast, an overly low political stake, $b < \underline{b}(q)$, would lead to a stagnation of reform similarly as in the case of an overly high political stake.

Proposition 4. *If $q \leq \frac{E(\theta)}{2}$ and $q \leq b \leq E(\theta) - q$, "big bang" reform occurs in any equilibrium: R proposes an equilibrium and chooses an experiment π under which the reform would always be implemented regardless of its economic effect θ.*

5 Political Stake and Reform Dynamics: Comparative Cases

The model provides a roadmap for understanding how political motivation and economic rationale shape the dynamics of policy reform and experimentation. Following the guidance of the model, we present historical cases aligned with four stylized cases that focus on varying the parameters of the political stakes (b) and the status quo payoff (q).

Table 1: Reform and Experimentation

Outcomes	High Political Stake	Low Political Stake
Bad Status Quo	Under-Reform w. Experimentation Uganda, 1993-1997	Big Bang Kenya, 2010
Fine Status Quo	Stagnation Soviet Union, 1965	Over-Reform w. Experimentation Vietnam, 2009

5.1 Uganda, 1993-2004: High Political Stake, Bad Status Quo

In 1993, President Museveni's administration launched a sequence of reforms to decentralize the political system in Uganda. Pilot projects were first launched in 13 districts before decentralization was implemented at greater scales. It took Museveni's administration 10 years to launch another round of experiments, the Fiscal Decentralisation Strategy in 2002, aiming to strengthen the fiscal standing of local governments and improve the allocative efficiency of the Poverty Action Fund. The Fiscal Decentralisation Strategy was first implemented in 15 pilot regions and then at the national level in 2004. The incremental process of fiscal decentralization in Uganda was consistent with a scenario of under-reform due to cautious experimentation.

On political parameters, the country struggled with severe economic difficulties following decades of military dictatorship and civil conflicts in the early 1990s. With per capita gross domestic product of US$168 in 1993, Uganda was confronted with severe poverty. Although President Yoweri Museveni won a majority of the popular vote in the first general election, he faced challenges from losing candidates on the validity of the election. Insurgent groups imposed a quintessential threat to his leadership. This was consistent with a combination of relatively high political stakes and low status quo payoff.

5.2 Soviet Union, 1965 and 1973: High Political Stake, Fine Status Quo

In 1965, the Soviet leaders initiated a plan to rebuild the centralized industrial administration after the ousting of Khrushchev. Soviet economist Evsei Liberman

sketched the essential idea in an article entitled "Plans, Profits, and Bonuses." The reform plan proposed to grant greater bonuses and retained profits and decision autonomy to enterprise managers. The Soviet leaders first experimented with the reform at a very small scale. It was first implemented in two garment factories in Moscow and Gorky, and it was gradually expanded to 400 factories in large cities (Adam and Bacouël-Jentjens, 1989).

The new measures faced strong resistance at the beginning. Industrial bureaucrats were weakly incentivized to reform. Instructions from the ministries were often against the pursuit of profitability due to the lack of market-oriented pricing mechanisms. As a result, the reform measures were never implemented systemically, and they were largely halted in 1969. In 1973, Alexei Kosygin, the chairperson of the Council of Ministers, attempted to merge enterprises into associations at the regional level. Local party leaders resisted the reforms and again they were never fully implemented.

Despite the stagnation in reforms, the growth of gross domestic product during the Soviet Union's Eighth Five-Year Plan was maintained at 7 percent. This was a fairly good status quo considering the potential uncertainty of economic reforms. The political stakes of implementing economic reforms were exceptionally high given the internal political struggles of the Soviet regime. Those features suggest a combination of high political stakes and a fine status quo. Soviet history scholars suggest that the Soviet leaders may have deliberately chosen stagnation for the sake of maintaining political stability (Feygin, 2023).

5.3 Kenya, 2010: Low Political Stake, Bad Status Quo

In 2010, the Kenyan government embraced a devolved system through a wholesale reform. The new Constitution abolished provincial administrations and established 47 counties as subnational units, each headed by an elected governor and deputy governor who were limited to two five-year terms. The devolved system not

only expanded the counties' power over a wide range of local policies, such as education, health, and agricultural investments, but also facilitated county governments through a mandatory transfer of at least 15 percent of the national government's revenue to the counties (Kramon and Posner, 2011). These political changes were intended to mitigate the abuse of executive power against ethnic minorities. As former President Daniel arap Moi remarked, the institutional design was "designed to safeguard the integrity of small tribes which were in danger of being overwhelmed by larger tribes." (Morton, 1999)

The proposal received wide political support from both the incumbent Party of National Unity and the Orange Democratic Movement under the leadership of Prime Minister Raila Odinga. Meanwhile, the country's economic development was severely disrupted by the post-election violence in 2008. In light of Figure 3, this scenario is consistent with relatively low political stakes and a bad status quo. As a result, senior politicians from the Orange Democratic Movement stood along with the Party of National Unity in advocating for a strong presidential system (Kramon and Posner, 2011). This scenario resembles a big bang reform or experiment with type-I error (over-reform) in equilibrium.

5.4 Vietnam, 2009: Low Political Stake, Fine Status Quo

The Central Committee of the Communist Party of Vietnam proposed a reform to abolish the elected District People's Council in 2007. The reform proposal attempted to address the District People's Council's governance problems, such as elite capture and bureaucratic red tape. The pilot program selected 10 of the country's 63 provinces for implementation. The pilots obtained mixed results. The recentralized districts registered an increase in the delivery of public services aligned with the central government's priority, but performance in serving the demands of local constituents deteriorated (Malesky, Nguyen and Tran, 2014).

The economic status quo was fine at the time the reform was initiated. Vietnam

registered an average growth rate of 6-7 percent in 2000-08, one of the fastest in the world. Although local elites opposed the recentralization, it received support from the majority of the central and provincial leaders. Nguyen Tan Dung largely consolidated political power after gaining control of the National Steering Committee and the Ministry of Home Affairs and won a second term shortly afterward (Vuving, 2017). In light of the model, political stakes were present but they were not too large in the recentralization reform. The combination of a fine status quo and low political stakes is conducive to a reform with type-I error (over-reform), as our model suggests.

6 A Case Study on Household Responsibility System in China

The formal model provides a relevant theoretical framework for understanding the strategic interactions driving the dynamics of reforms and experiments. To provide a systemic empirical illustration, we focus on the implementation of the HRS in China. First, the central leadership of the Communist Party of China (CPC) was divided into two groups, the reformist group and the conservative group, who held diverging positions on a wide range of policy issues. Second, adoption of the HRS was initially a highly contested issue, and experiments were carried out at the local level between 1978 and 1982. The prevailing view of the HRS was associated with a political gain by the reformist group, as indicated by its dominance in personnel appointments and economic policy making.

Implementation of the HRS in China's agriculture sector in the 1980s resulted from a sequence of policy experiments and piecemeal reforms. A local experiment with the HRS emerged in 1978, somewhat spontaneously, when 18 households in a small village in Fengyang in Anhui province signed a closed-door deal with the village committee. Rural households obtained rights to manage cultivation on their own parcels and contract with the local government. From the incentive perspective, this arrangement granted peasants the position of residual claimants for grain yields

after fulfilling procurement and tax duties.

The HRS experiment in Fengyang was endorsed by Wan Li, who was then the newly appointed first party secretary of the CPC in Anhui province, which had a long history of battling disasters and famines in the past centuries. In 1960-62, Anhui was one of the provinces with the largest death tolls during the Great Leap Forward movement. The province suffered another drought and faced severe food shortages in the first half of 1978. To alleviate economic difficulties in the rural sectors, Wan Li took the initiative to promote the "Six Guiding Principles by the Provincial Party Committee for Agriculture," granting production teams greater control over farming and encouraging farmers to cultivate the wastelands. This circumstance is consistent with a low status-quo payoff (q) in light of the model.

However, the reform dynamics may have been deterred by prohibitively high political tension. In turn, although the Third Plenary Session of the 11th Central Committee of the CPC in 1978 was officially regarded as the opening of China's economic reform, it did not result in clear support for the HRS. The inconsistency between the economic rights of private households and the orthodoxy of collective farming presented a dilemma for the CPC's central leadership in terms of the HRS.

The official provincial newspapers in several provinces, including Beijing, Shanxi, Hunan, Jiangxi, Henan, and Jiangsu, launched large waves of attacks on the HRS. In Jiangsu province, local governments set up loudspeakers along the border with Anhui and broadcasted the message that the people should "resolutely oppose dividing the lands and redistributing to households." In Shanxi province, where the famous Dazhai model of collective farming was praised by Mao and enthusiastically followed by other provinces during the Cultural Revolution, the official Shanxi Daily published 12 editorials to defend Dazhai, casting a doubt on the HRS.[1]

[1]For example, Shanxi Daily published an editorial entitled "Xiyang is good case of mobilizing farmers' socialist enthusiasm", stating harshly that "Dazhai people keep in mind the basic line of the party. They believe that if we cannot take one step farther toward socialism without blocking the path to capitalism. The failure of the leadership to take a clear position on this issue will perplex people's views, push us toward an increasingly unhealthy trend of capitalism, and destroy the socialist economy."

The divergence on the HRS as late as 1980 reflected a clear ideological division within the CPC's leadership. At the central level, the division over the HRS stemmed from a deeply rooted power struggle between two factions, the reformists led by Deng Xiaoping and the conservatives led by Hua Guofeng, who was the chairperson of the CPC and the premier of the state council. To countervail criticisms, reformists published an article entitled "An important experience of implementing agricultural policies in Chu county of Anhui province" in the People's Daily on July 6, 1978. The article took a highly politicized tone in making the case for household responsibility, arguing that resistance to the HRS was against the Party's basic line and undermined the energy of the socialist economy in the rural sector. As a result, the Third Plenary Session ended with the compromise of "devolving production responsibility to production teams" and imposing an official restriction on delegating production responsibility to households.

The HRS experiment started to diffuse in 1980, after Wan Li was promoted to vice premier and head of the National Committee of Agriculture. It took the CPC leadership six years (1978-84) to establish the HRS at the national level. Empirical research has provided compelling evidence that implementation of the HRS greatly enhanced agricultural productivity in China (Lin, 1992). This was a case of under-reform with experimentation as illustrated by the red curve in Figure 3. The HRS would have yielded better outcomes had it been implemented earlier and in a top-down fashion.

Examining the policy dynamics of the HRS through the lens of the model produces two readily testable arguments. First, the transition from the status quo economic system (collective farming) to local experimentation with the HRS may have been associated with a decline in the political stakes at the national and sub-national levels. In Figure 3, this is indicated by a change in parameter conditions from the "Stagnation" region to the "Under-reform" region. Second, the probability of implementing a local experiment with the HRS was nonmonotonically correlated

with the level of the political stakes (b). Specifically, local experimentation was likely to occur when the political stakes were neither too high nor too low. The subsequent sections examine these two propositions empirically.

6.1 Decline of Political Stake

To examine the two arguments presented above, we manually collected information on the HRS reform at the county level from 1,755 county gazettes. By the end of 1983, more than 98 percent of the production teams had implemented the HRS. Moreover, the Central Committee of the CPC formally disbanded the people's communes in 1983 and recognized the HRS in the Chinese Constitution in 1987. For our purpose, the experiment with the HRS in 1978-83 had political implications for local leaders.

Following the reasoning in section 4, we define a county as a local experimenter if it initially implemented the HRS before January 1982, and not an experimenter (that is, stagnation) if otherwise. The key parameter in our analysis is the level of the political stakes, which we capture empirically by the potential for power struggle among competing factions within the provincial standing party committees. We first code three types of factional affiliations of provincial leaders: potential reformist if he or she was persecuted during the Cultural Revolution and reappointed after 1976; conservative if he or she took an active part in the political campaign during the Cultural Revolution as an incumbent officer; and centrist if the leader was neither persecuted nor active during the Cultural Revolution. The rationale of this coding scheme is that party cadres who were persecuted during the Cultural Revolution were likely to be in political alliance with Deng Xiaoping in putting forward economic reforms during the 1980s. By contrast, most cadres who were in active duty during the Cultural Revolution were likely politically aligned with Mao or the Gang of Four, and hence they were unlikely to have been allies of Deng. We define the index of political stakes at the province level according to the

relative balance of power between the two rival factions, the conservatives and the reformists, as follows:

$$\text{Stake} = 1 - \left| \frac{\text{N}_\text{C} - \text{N}_\text{R}}{\text{N}_\text{C} + \text{N}_\text{R}} \right| \tag{12}$$

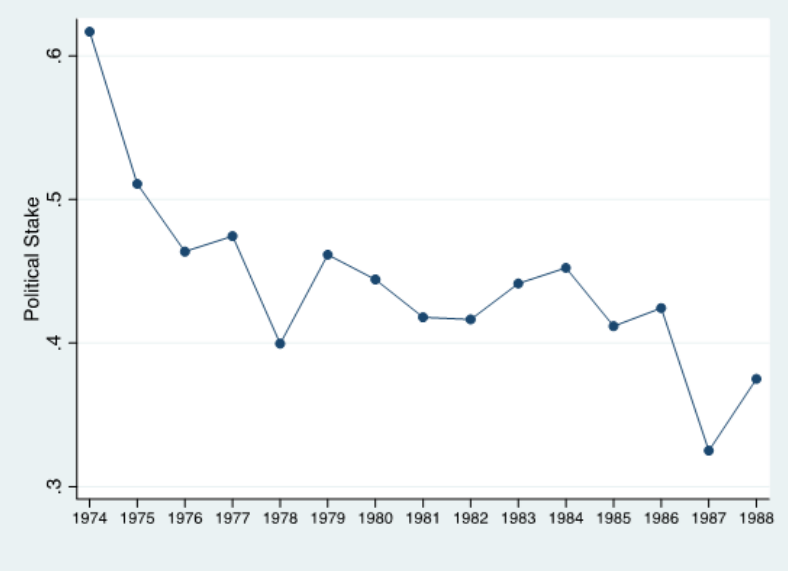
The range of the political stakes index is $[0,1]$. A larger value of the index indicates that the two rival factions maintained a balance of contesting power, and thus the stakes of prevailing politically were high. When the value of the index is close to zero, one faction dominates, and the stakes are small. For example, Anhui and Sichuan are a case in point. In 1979, the reformists were the leading members of the Standing Committee in Anhui province, where Wan Li was the first provincial party secretary. The political stakes index for Anhui in 1979 is relatively small (0.24). Consistent with the low political stakes, in Anhui, 25.9 percent of the counties were implementing the HRS in 1979. By a similar token, the political stakes in Sichuan in 1979 were about 0.57. Implementation of the HRS in Sichuan was significantly slower: only 18.8 percent of the counties had implemented the reform in 1979.

Figure 4 presents the trend of the average of the counties' political stakes in 1974-88. The highest level of political stakes at the national level was in 1974. The period 1977-79 witnessed fluctuation in the political stakes, reflecting a potential power struggle and personnel turnovers in the provincial party standing committees. Following Deng's consolidation of power in 1979, the political stakes index assumed a declining trend. The political stakes decreased further after 1985 due to the dominance of political leaders in Deng Xiaoping's coalition.

6.2 Political Stake and Experimenter

The second argument that can be tested with the formal model is that the relationship between the political stakes and the probability of being an experimenter follows an inverted U-shape. That is, the probability is the highest when the value

Figure 4: Changing Political Stake Over Time



Notes: This graph shows the annual level of the political stakes index, computed as the arithmetic average of province-level political stakes measured by Equation (12).

of political stakes is at an intermediate level. We estimate the probability that a county was an experimenter as follows.

$$\text{Experimenter}_\text{i} = \text{Constant} + \alpha \cdot \text{Stake} + \beta \cdot \text{Stake}^2 + \gamma \text{X}_\text{i} + \epsilon_\text{i} \tag{13}$$

In Equation (13), the subscript i represents the county. $\text{Experimenter}_\text{i}$ is a dummy variable indicating whether the county was an experimenter or not. The key explanatory variables are *Stake* and $Stake^2$, where the value of *Stake* is provided by Equation (12). We expect that the estimate for α is positive and that for β is negative. The vector X_i contains several variables that may be correlated with the speed of the reform, such as the logarithm of the total agricultural production in 1978, and a dummy variable indicating whether the province's first party secretary was identified as a reformer or not.

Table 2 presents the main results. Consistent with the theoretical prediction, the results in all columns consistent report a positive coefficient of α and a negative

Table 2: The Probability of Being an Experimenter

	Dependent variable: 1(Early Reformer)				
	(1)	(2)	(3)	(4)	(5)
Political Stake	0.928***	0.844**	1.025***	1.114**	4.976**
	(0.298)	(0.380)	(0.299)	(0.457)	(2.051)
(Political Stake)^2	-0.935***	-0.992***	-0.947***	-1.239***	-5.532***
	(0.284)	(0.367)	(0.284)	(0.471)	(2.118)
Log(Agricultural production)		0.0228		0.027	0.122
		(0.0192)		(0.025)	(0.114)
P.S. Reformer			0.157***	-0.398*	-1.780
			(0.0405)	(0.248)	(1.114)
Constant	0.298***	0.0305	0.206***	0.0871	-2.325**
	(0.0687)	(0.190)	(0.0725)	(0.195)	(1.148)
Observations	1,357	666	1,357	666	473
R^2	0.009	0.020	0.019	0.030	0.032

Robust standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Columns 1-4 report the results based on linear estimation. Column 5 reports the marginal effects based on a logit estimation.

coefficient of β. The turning point of the inverse-U relationship occurs somewhere around 0.5, which is close to the 66th percentile of the political stake index among all the counties in the regression sample. Column (5) presents the marginal effects from a logit estimation. These results lend cautious empirical support to the game-theoretical analysis presented in sections 3 and4.

7 Conclusion

Governments around the world vary considerably in their reform pathways. Some get stuck in the early stage and cannot engage in further meaningful policy discussion. Some pursue reforms partially, leading to conflicts and reversal of policies. In a handful scenarios, incumbents act more decisively, implementing reforms in a big bang fashion regardless of political resistance. And finally, there are cases in which incumbents implement policy reforms and gain politically. To make sense of the variation in reform dynamics, researchers have noted that politicization of a policy may impede reform and stimulate conflicts (Bussmann and Schneider, 2007; Hartzell, Hoddie and Bauer, 2010).

This paper developed a model of Bayesian persuasion to study reform through policy experimentation, where the incumbent and opposition factions share a common economic interest but are divided in their political stances. The model shows that experimentation may be conducive to a larger probability of reform through eliciting information. However, experimentation in equilibrium almost never elicits information perfectly when the policy involves political stakes. The optimal experiment is conducive to type-I error (over-reform) when the stakes are large and type-II error (under-reform) when the stakes are small. In turn, reform through experimentation is most likely to occur when the political stakes are distributed within an intermediate range. As such, the model reconciles the empirical findings of biased policy experimentation in the recent literature (Wang and Yang, 2021) with the theoretical works on policy experimentation.

This paper showed that reform can be contentious even though the key players are fundamentally aligned on economic interests. The effect of the political stakes is contingent on the political-economic environment. A moderate degree of political stakes enhances the probability of reform with the help of experimentation.

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Proof of Lemma 1.

Necessity. Suppose p is feasible. Then, there exists an experiment π such that $p(\theta) = p_\pi(\theta)$ holds for all $\theta \in \Theta$. Note that by definition, for all $\theta \in \Theta$,

$$p_\pi(\theta) = \pi\left(E(\theta|s,\pi) \geq q+b|\theta\right) = p(\theta).$$

If $\int_\Theta p(\theta)dF(\theta) > 0$,

$$\int_\Theta \pi\left(E(\theta|s,\pi) \geq q+b|\theta\right) dF(\theta) = \pi\left(E(\theta|s,\pi) \geq q+b\right) > 0.$$

Then,

$$E\left(\theta|s \in \{E(\theta|s,\pi) \geq q+b\}\right) - q + b = \frac{\int_\Theta p(\theta)\left(\theta-(q+b)\right)dF(\theta)}{\int_\Theta p(\theta)dF(\theta)} \geq 0,$$

which implies that

$$\int_\Theta p(\theta)\left(\theta-(q+b)\right)dF(\theta) \geq 0.$$

Similarly, if $\int_\Theta p(\theta)dF(\theta) < 1$, $\pi\left(E(\theta|s,\pi) < q+b\right) > 0$, so that

$$E\left(\theta|s \in \{E(\theta|s,\pi) < q+b\}\right) - q + b = \frac{\int_\Theta \left(1-p(\theta)\right)\left(\theta-(q+b)\right)dF(\theta)}{\int_\Theta \left(1-p(\theta)\right)dF(\theta)} < 0,$$

which implies that

$$\int_\Theta \left(1-p(\theta)\right)\left(\theta-(q+b)\right)dF(\theta) < 0.$$

Sufficiency. Suppose p satisfies (3) and (4). Let π be such that $S_\pi = \{0,1\}$ and $\pi(s=1|\theta) = p(\theta)$ for all $\theta \in \Theta$. First, suppose $\int_\Theta p(\theta)dF(\theta) > 0$, then

$$E(\theta|s=1,\pi) - (q+b) = \frac{\int_\Theta p(\theta)\left(\theta-(q+b)\right)dF(\theta)}{\int_\Theta p(\theta)dF(\theta)} \geq 0,$$

so that $m^*_\pi(s=1) = 1$. Second, suppose $\int_\Theta p(\theta)dF(\theta) < 1$, then

$$E(\theta|s=1,\pi) - (q+b) = \frac{\int_\Theta \left(1-p(\theta)\right)\left(\theta-(q+b)\right)dF(\theta)}{\int_\Theta \left(1-p(\theta)\right)dF(\theta)} < 0,$$

so that $m^*_\pi(s=0) = 0$. It follows that $p_\pi(\theta) = p(\theta)$ holds for all $\theta \in \Theta$. ∎

Proof of Proposition 1. We solve the less constrained problem

$$\begin{aligned} \max_{p:\Theta\to[0,1]} \quad & \int_\Theta p(\theta)\left(\theta-(q-b)\right)dF(\theta) \\ \text{s.t.} \quad & \int_\Theta p(\theta)\left(\theta-(q+b)\right)dF(\theta) \geq 0 \end{aligned} \tag{A.1}$$

and show that the solution satisfies (4), so that it must be a solution to (8). Let $\lambda \geq 0$ be the Lagrangian multiplier of the constraint of program (A.1), then the first order condition of this program implies that

$$p(\theta) = \begin{cases} 1, & \text{if} \quad \theta - (q-b) + \lambda(\theta - (q+b)) \geq 0 \\ 0, & \text{if} \quad \theta - (q-b) + \lambda(\theta - (q+b)) < 0 \end{cases}.$$

Hence, the solution to (A.1) must be a cutoff function $p(\theta) = \mathbb{I}\{\theta \geq k\}$ for some $k \in \mathbb{R}_+$. It follows that problem (A.1) is equivalent to the simplified problem

$$\begin{aligned} \max_{k \in \mathbb{R}_+} \quad & u(k|b,q) := \int_k^\infty (\theta - (q-b))\, dF(\theta) \\ \text{s.t.} \quad & E(\theta|\theta \geq k) \geq q + b. \end{aligned} \tag{A.2}$$

Define $b^*(q)$**.** Note that

$$E(\theta|\theta \geq q-b) - (q+b)$$

is strictly decreasing in b. Then, because $E(\theta|\theta \geq q) - q > 0$ and because

$$E\left(\theta|\theta \geq q - (E(\theta|\theta \geq q) - q)\right) - (q + E(\theta|\theta \geq q) - q) < E(\theta|\theta \geq q) - E(\theta|\theta \geq q) = 0,$$

equation $E(\theta|\theta \geq q-b) - (q+b)$ admits a unique root $b^*(q) \in (0, E(\theta|\theta \geq q) - q)$.

The case when $b < b^*(q)$**.** When $b < b^*(q)$, the unconstrained maximizer of $u(k|b,q)$, $k = \max\{0, q-b\}$ satisfies

$$E\left(\theta|\theta \geq \max\{0, q-b\}\right) \geq E(\theta|\theta \geq q-b) > E\left(\theta|\theta \geq q - b^*(q)\right) = q + b^*(q) > q + b.$$

Hence, $k = \max\{0, q-b\} = k^*(b,q)$ uniquely solves (A.2). Let $p(\theta) = \mathbb{I}\{\theta \geq k^*(b,q)\}$. If $\int_\Theta p(\theta) dF(\theta) < 1$, then $k^*(b,q) = q - b > 0$, which implies that

$$\int_\Theta (1 - p(\theta))\, (\theta - (q+b))\, dF(\theta) = \int_0^{q-b} (\theta - (q+b))\, dF(\theta) < 0,$$

so that p satisfies (4).

The case when $b \geq b^*(q)$**.** Now suppose $b \geq b^*(q)$. Then, for all k such that $E(\theta|\theta \geq k) > q + b$, $k > q - b$, so that

$$u'(k|b,q) = -(k - (q-b))\, f(k) < 0.$$

Hence, the solution of (A.2) must be the smallest k that satisfies the constraint $E(\theta|\theta \geq k) \geq q$, that is,

$$k = \min\{k \in \mathbb{R}_+ : \ E(\theta|\theta \geq k) \geq q + b\} = k^*(b,q).$$

Let $p(\theta) = \mathbb{I}\{\theta \geq k^*(b,q)\}$. If $\int_\Theta p(\theta) dF(\theta) < 1$, then $k^*(b,q) > 0$ and must satisfy

$$E\left(\theta|\theta \geq k^*(b,q)\right) = q + b,$$

so that $k^*(b,q) < q+b$. As a result,

$$\int_\Theta (1-p(\theta))\,(\theta-(q+b))\,dF(\theta) = \int_0^{k^*(b,q)} (\theta-(q+b))\,dF(\theta) < 0,$$

so that p satisfies (4). ∎

Proof of Proposition 2. As shown in the proof of Proposition 1,

$$b^*(q) < E(\theta|\theta \geq q) - q = \hat{b}(q).$$

According to Proposition 1, the optimal conditional probability of implementation produces over-reform if and only if $k^*(b,q) < q$. This never holds when $b \leq b^*(q)$, because in this case $k^*(b,q) = \max\{q-b,0\} < q$. For $b > b^*(q)$, $k^*(b,q) < q$ holds if and only if

$$E(\theta|\theta \geq q) > q+b,$$

which is equivalent to $b < E(\theta|\theta \geq q) - q = \hat{b}(q)$. Hence, the optimal conditional probability of implementation produces over-reform if and only if $b < \hat{b}(q)$. The same steps prove that the optimal conditional probability of implementation produces under-reform if and only if $b > \hat{b}(q)$.

By the definition of $k^*(b,q)$, $k^*(b,q) = \max\{q-b,0\}$ is decreasing in $b < b^*(q)$ and $k^*(b,q) = \min\{k \in \mathbb{R}_+ :\ E(\theta|\theta \geq k) \geq q+b\}$ is increasing in b. Then, because for each $k < q$,

$$\frac{F(q)-F(k)}{1-F(k)} = 1 - \frac{1-F(q)}{1-F(k)}$$

is strictly decreasing in k. Hence,

$$\frac{F(q)-F\left(k^*(b,q)\right)}{1-F\left(k^*(b,q)\right)}$$

is increasing in $b < b^*(q)$ and decreasing in $b \in \left(b^*(q), \hat{b}(q)\right)$. Similarly,

$$\frac{F(k)-F(q)}{F(k)} = 1 - \frac{F(q)}{F(k)}$$

is strictly increasing in k. Hence,

$$\frac{F\left(k^*(b,q)\right)-F(q)}{F\left(k^*(b,q)\right)}$$

is decreasing in $b > \hat{b}(q) > b^*(q)$. ∎

Proof of Proposition 3. First, when $b < b^*$, $k^*(b,q) = \max\{q-b, 0\}$, so that

$$\frac{\partial}{\partial b} v(b,q) = -\left(k^*(b,q) - (q-b)\right) f\left(k^*(b,q)\right) + 1 - F\left(k^*(b,q)\right) > 0.$$

Hence, $v(b,q)$ is strictly increasing in $b < b^*(q)$. Now suppose $b \geq b^*(q)$. Then,

$$E\left(\theta | \theta \geq k^*(b,q)\right) = q + b,$$

so that

$$\int_{k^*(b,q)}^{\infty} \left(\theta - (q+b)\right) dF(\theta) = \int_{k^*(b,q)}^{\infty} \left(\theta - (q-b)\right) dF(\theta) - 2b\left(1 - F\left(k^*(b,q)\right)\right) = 0$$

and, therefore,

$$v(b,q) = 2b\left(1 - F\left(k^*(b,q)\right)\right).$$

Moreover, the definition of $k^*(b,q)$ implies that

$$\frac{\partial}{\partial b} k^*(b,q) = \frac{1 - F\left(k^*(b,q)\right)}{f\left(k^*(b,q)\right)} \frac{1}{q + b - k^*(b,q)}.$$

Hence,

$$\begin{aligned} \frac{\partial}{\partial b} v(b,q) &= 2\left(1 - F\left(k^*(b,q)\right)\right) - 2b f\left(k^*(b,q)\right) \frac{\partial}{\partial b} k^*(b,q) \\ &= 2\left(1 - F\left(k^*(b,q)\right)\right) \frac{q - k^*(b,q)}{q + b - k^*(b,q)} \end{aligned}$$

has the same sign with $q - k^*(b,q)$, which is positive if and only if $b < \hat{b}(q)$. Therefore, $v(q,b)$ is single-peaked in b. It is strictly increasing in $b < \hat{b}(q)$, strictly decreasing in $b > \hat{b}(q)$, and is maximized at $b = \hat{b}(q)$.

Second, because f is log-concave, $E(\theta | \theta \geq q) - q$ is decreasing in q, so that

$$v\left(\hat{b}(q), q\right) = 2\left(E(\theta | \theta \geq q) - q\right)\left(1 - F(q)\right)$$

is strictly decreasing in q. Then, because $v\left(\hat{b}(0), 0\right) = 2E(\theta) > \delta$ and because $\lim_{q \to \infty} v\left(\hat{b}(q), q\right) = 0 < \delta$, equation $v\left(\hat{b}(q), q\right) = \delta$ admits a unique root $\overline{q} \in (0, \infty)$ and $v\left(\hat{b}(q), q\right) \geq \delta$ holds if and only if $q \leq \overline{q}$. Similarly,

$$v(0,q) = \int_q^{\infty} (\theta - q) dF(\theta) = \left(E(\theta | \theta \geq q) - q\right)\left(1 - F(q)\right) = \frac{v\left(\hat{b}(q), q\right)}{2}$$

is strictly decreasing in q. Then, because $v(0,0) = E(\theta) > \delta$ and $v(0, \overline{q}) = \delta/2 < \delta$, equation $v(0,q) = \delta$ admits a unique root $\underline{q} \in (0, \infty)$ and $v(0,q) \geq \delta$ holds if and only if $q \leq \underline{q}$.

Third, suppose $q > \overline{q}$. Then,

$$v(b,q) \leq v\left(\hat{b}(q),q\right) < \delta$$

holds for all $b \in \mathbb{R}_+$. Suppose $q \leq \underline{q} < \overline{q}$. Then, because $v(b,q)$ is single-peaked in b, $v(0,q) \geq \delta$, $v\left(\hat{b}(q),q\right) > \delta$, and $\lim_{b\to\infty} v(b,q) = 0 < \delta$, equation $v(b,q) = 0$ about b admits a unique root $\overline{b}(q) \in (\hat{b}(q),\infty)$ on $(0,\infty)$ and $v(b,q) \geq \delta$ holds if and only if $b \leq \overline{b}(q)$. At last, suppose $\underline{q} < q \leq \overline{q}$. Then, because $v(b,q)$ is single-peaked in b, $v(0,q) < \delta$, $v\left(\hat{b}(q),q\right) > \delta$, and $\lim_{b\to\infty} v(b,q) = 0 < \delta$, equation $v(b,q) = 0$ about b admits two roots $\underline{b}(q) \in \left(0,\hat{b}(q)\right]$ and $\overline{b}(q) \in \left[\hat{b}(q),\infty\right)$ and $v(b,q) \geq \delta$ holds if and only if $\underline{b}(q) \leq b \leq \overline{b}(q)$. ■

Proof of Proposition 4. By the definition of $k^*(b,q)$, $k^*(b,q) = 0$ holds if and only if $q \leq b$ and $E(\theta) \geq q + b$. The second condition is equivalent to $b \leq E(\theta) - q$. Hence, $k^*(b,q) = 0$ holds if and only if $q \leq b \leq E(\theta) - q$ and this condition necessitates $q \leq E(\theta)/2$. ■