Machiavellian experimentation[☆]

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A B S T R A C T

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This paper proposes the following mechanism whereby polarization of beliefs could eliminate political gridlock instead of intensifying disagreement: the expectation of political payoffs from being proven correct by a policy failure could drive decision makers who do not believe in the new policy to agree to policy experimentation, because they are confident that the experiment will fail, thus increasing their political power. We formalize this mechanism in a collective decision making model in the presence of heterogeneous beliefs in which any decision other than the default option requires unanimity. We show that this consideration of political payoffs can eliminate the inefficiency caused by a unanimous consent requirement when beliefs are polarized, but could also create under-experimentation when two actors hold beliefs that differ only slightly from one another. We further show that this under-experimentation can be reduced when the political payoffs become endogenous. We illustrate the empirical relevance of the mechanism in two examples with historical narratives: we focus on the decision making process of the Chinese leadership during the country's transition starting in the late 1970s, and we further apply the model to the disagreement within the leadership of the Allied Forces on the Western Front of World War II in the autumn of 1944. *Journal of Comparative Economics* **45** (2017) 685–711. Department of Economics, Columbia University, 420 West 118th Street, 1022 International Affairs Building, New York, NY 10027, USA; Department of Economics, University of California, Riverside, 900 University Avenue, 4128 Sproul Hall, Riverside, CA 92521, USA.

1. Introduction

In real-world policymaking, policy changes that implement a new idea often require collective decision making by actors who have different beliefs about the effectiveness of the idea. In this situation, we might expect polarization of beliefs to intensify disagreement and result in political gridlock, since the decision maker who holds an extremely pessimistic view about the new idea would oppose its implementation. This paper, however, proposes a mechanism by which polarization of beliefs could do the opposite – it could motivate decision makers to agree upon policy experimentation, but by a Machiavellian consideration: the opponents of the policy are confident that they will gain political power relative to their colleagues after the experiment, because they believe that the experiment will prove them correct and their colleagues wrong.

This mechanism is primarily motivated by investigating an important question in political and development economics and economic history. The question is why China adopted a gradual, piecemeal, and experimental approach in its transition from the planned economy, starting in the late 1970s, instead of pursuing more of a full-scale, "Big Bang" approach, as the all-at-once approach is called in the literature (e.g., the surveys by Roland, 2000, 2002). Conventional wisdom assumes that the Chinese leaders were not certain about the outcome of pursuing the market reform, so they decided not to risk a more overarching reform. A more nuanced reading of the situation emerges, however, when we recognize the two prominent characteristics of Chinese politics of the time. First, from the late 1970s through the 1980s, there were opposing beliefs about market reform among the Communist Party leadership, with the conservative faction extremely conservative. Second, any radical policy change required consensus among the Party leadership. These observations transform the question into why the extremely conservative faction did not veto the experimental reform.

The key to the question is to recognize the political impact of learning through an experimental approach when heterogeneous beliefs exist. Not only can an experiment provide information about a particular reform; it can also indicate which faction was correct, and which incorrect. The correct side can expect to be rewarded in the form of stronger political power, while the incorrect side should be punished. If the two factions hold diametrically opposite beliefs, then *both* of them would be very confident in being proven correct by the experiment's result, and thus in being rewarded. Therefore, if the expected reward is sufficiently large, *both* of them would agree to the experimental approach.[1]

We formalize this mechanism of Machiavellian experimentation by use of a model in which two players within the same organization decide together whether and how to adopt a new policy. There are three options – a Big Bang approach with full-scale adoption; a pilot approach in which adoption will begin on a small scale and then be either generalized or stopped based on the experiment's result; and a default option in which no change occurs. The model has three key assumptions, which are tailored to the context of the Chinese transition but can be generalized beyond it.

Different priors. The two players have different priors about whether the policy will be effective in achieving the desired results, this disagreement is common knowledge, and the players do not infer anything from this disagreement. We label the player who holds the more optimistic belief about the policy *the reformer*, and the other player *the conservative*. Different priors commonly exist in politics, business, and other public or private policymaking (e.g., Sabatier, 1988; Bendor and Hammond, 1992; Mutz, 2008; Minozzi, 2013; Millner et al., 2014; Hirsch, 2016). This is the case because people can be endowed with different priors, just as they can be endowed with different preferences, and people can interpret public information in different ways under different psychological, cultural, or historical backgrounds. Different priors are especially prominent in intra-organizational debates if the organizations, e.g., technology-based companies, compete in a fast-changing environment (Eisenhardt et al., 1997). As seen in a significant and growing literature in economics, management, and political science (e.g., Van den Steen, 2002, 2010a, 2010b, 2010c; Che and Kartik, 2009; Millner et al., 2014; Hirsch, 2016), this assumption is useful in studying the implications of open belief disagreement.[2]

Consensus requirement. Any adoption of the policy requires consensus; otherwise, nothing will happen. In other words, both players can veto any adoption. It is common to see a consensus requirement in real world decision-making. For example, in the United States, the jury in a federal court must reach a unanimous verdict. In the Council of the European Union, decision-making about certain policy questions requires unanimity in voting. In the German two-tier board system of corporate governance, only decisions that garner consensus within the *Vorstand* (management board) will be referred to the *Aufsichtsrat* (supervisory board) for approval (Charkham, 1994). Consensus is usually required to protect decision makers from repercussions of unpopular decisions or to demonstrate unity to those outside the decision making process (e.g., Visser and Swank, 2007). Even if a consensus requirement is not explicitly written into decision-making rules, it can also apply *de facto* when decision makers are equally powerful, as we see in the example of the Chinese transition.

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[1] A two-sentence explanation of our title, *Machiavellian Experimentation,* is needed here. First, as the reader might have already seen, we use the word, Machiavellian, in the general sense that the mechanism we propose is political, strategic, calculating, and somehow cynical. Second, one episode in Niccolò Machiavelli's *The Prince* (1947) contains a similar idea: just before the Second Italian War, in 1498, Pope Alexander VI did not oppose the Venetians' plan to invite Louis XII of France back to Italy, but "facilitated it by the annulment of the first marriage of King Louis," expecting that the coming of the French would eventually weaken the Venetians by creating disorder among the Italian states and helping the Pope and his son, Cesare Borgia, acquire Romagna, a strategic area in Italy.

[2] Theoretical works with heterogeneous priors can be traced back to Arrow (1964). Another tradition following Harsanyi (1967, 1968a, 1968b) and Aumann (1976) rules out "agreeing to disagree." For extensive discussions about preserving or breaking the common prior assumption, see Morris (1995), Gul (1998), Che and Kartik (2009), and Hirsch (2016).

Contingent, mutually exclusive payoffs. After the experiment demonstrates whether the policy achieved the desired result, the player whose side was proven correct receives some reward, while the other player is punished. We call the reward and punishment *contingent, mutually exclusive payoffs*, since the payoffs are contingent on the players' priors and the experiment's result, and they always reward one player and harm the other. Contingent, mutually exclusive payoffs are common, since people often derive profit, power, or joy simply from being proven correct, and suffer economically, politically, and psychologically from being proven incorrect. The generality and the importance of the contingent, mutually exclusive payoffs can also be shown by contradiction: if people did not care about these types of payoffs, then they would be indifferent between being proven correct and incorrect. In reality, however, people usually hope to be proven correct (and shun the notion of being proven incorrect) when experimentation brings new information. For example, managers know that good results of their experimental decisions would strengthen their position in the labor market, and, if politicians are facing fierce political competition, they would acknowledge that failed policy experiments could reveal their incompetence and drive votes away.

To show the role of the contingent, mutually exclusive payoffs in the realm of experimentation, we start with a benchmark model including only the first two key assumptions – different priors and the consensus requirement. At this point, we assume that the payoffs are not mutually exclusive, which we call *mutually inclusive payoff*. We show two simple but fundamental results. First, if the conservative sufficiently disbelieves in the policy prescription, then neither the Big Bang approach nor the experimental approach will be adopted, no matter how strongly the reformer believes in the proposed policy. This result comes from the conservative's veto power and corresponds to the view that polarization of beliefs could cause political stalemate. Second, it is possible for the experimental approach to be adopted *only* if the conservative has a moderate prior toward the reform. This result comes from not only the conservative's veto power but also our assumption that the players both consider the trade-off between the Big Bang approach and the experimental approach in classic terms, weighing option values and delayed costs, so it corresponds to the conventional wisdom that associates experimentation with moderate beliefs. This benchmark model can be regarded as an extension of Dewatripont and Roland (1995) from a single decision maker to two decision makers.

We then introduce the third key assumption – contingent, mutually exclusive payoffs – to the benchmark model and compare the new model to the benchmark. We show that, when players care strongly about the contingent, mutually exclusive payoffs, 1) if the players hold diametrically opposite beliefs, then the experimental approach will be adopted; 2) if at least one of the players holds a moderate belief, then no new policy will be adopted. The intuition is that only diametrically opposite beliefs can guarantee *both* that the conservative is confident of getting the contingent reward from the experiment and that the reformer is also confident of avoiding the contingent punishment. The two results associate experimentation with extreme beliefs, in contrast to the former association with moderate beliefs.

Given this main result, we then analyze its welfare implications, asking under what conditions the organization benefits from consideration of the contingent, mutually exclusive payoffs – in other words, when do political considerations lead to good outcomes? We show that the consideration of politics is desirable when the players' priors are diametrically opposite but it can be undesirable when the priors are only slightly different.

As an extension, we then endogenize the contingent, mutually exclusive payoffs by granting the players an option to tacitly agree to mute these payoffs by concealing their different beliefs from outsiders. We show that players with diametrically opposite beliefs will not choose this option and will still pursue the contingent, mutually exclusive payoffs by agreeing on experimentation. By contrast, players with slightly different beliefs can cooperate to use this option and reach experimentation, considering only the mutually inclusive payoff. This extension suggests that endogenizing contingent, mutually exclusive payoffs has the result that consideration of these payoffs can be beneficial for the organization regardless of the difference in beliefs.

After the theoretical analysis, we will apply our model to interpret the strategy choice of the Chinese transition in more detail. We will fit the three key elements of our model with history, reject the benchmark model, show support for the empirical relevance of our mechanism of Machiavellian experimentation, and compare our explanation with alternative considerations. Our interpretation of the Chinese transition is closer to the perspective of Shirk (1993, 1994), which discusses the politics among politicians, than to the view of Acemoğlu and Robinson (2012), which evaluates the politics between politicians and the people. Our case study provides an example of the case studies that focus on the motivations behind formations of important political coalitions in history, which have been recognized by Bardhan (2016) to be valuable in understanding the relation between state and development.

Although the proposed mechanism is motivated by the Chinese transition, and we try to follow the principle of Occam's Razor in formalizing the mechanism, our model is not limited to China, and can apply to other situations, e.g., public policy debates, international affairs, and even financial transactions. In the latter part of this paper, we will further illustrate our model with another important historical example: the disagreement within the leadership of the Allied Forces on the Western Front of World War II in the autumn of 1944, namely between Dwight Eisenhower and Bernard Montgomery, and their decision to implement Operation Market–Garden, one of the most heroic but disastrous failures (from the viewpoint of the Allies) in the history of modern warfare. In this illustration, we critically analyze the memoirs of witnesses (e.g., Montgomery, 1947, 1958; Eisenhower, 1948, 1970) and works by historians (e.g., Eisenhower, 1986; Ambrose, 1990, 2012; Murray, 1996; D'Este, 2002; Brighton, 2008), and, again, establish the link between history and the assumptions, predictions, and mechanism of our model. Finally, we discuss the limitations of other potential interpretations.

We proceed in the paper as follows: The rest of this section clarifies the position of our paper in literature. Section 2 builds the benchmark model and Section 3 solves it. Section 4 introduces contingent, mutually exclusive payoffs to the benchmark model and shows our main result. Section 5 discusses welfare implications. Section 6 endogenizes the contingent, mutually exclusive payoffs. Section 7 illustrates the model with the two historical examples. Section 8 concludes the paper by discussing broader applications of our key logic. Proofs, further analysis, and other extensions of the model are presented in appendices.

Position in literature. There exist at least two papers investigating a question similar to ours: why, on many important issues, do policymakers choose policy options that are apparently contrary to their interests or beliefs?[3] One paper by Callander and Hummel (2014) models the idea that a conservative with temporary control of power would initiate an experimental, "preemptive" reform, wishing the unintended outcomes to shape the information available to the succeeding reformer in a way that favors the conservative agenda. Their logic and our logic are similar only on the surface. In their logic, given that the predecessor will lose power, she experiments in order to influence the information that the successor will face. In our logic, however, the conservative experiments because she expects to gain power, not because she would like to change the reformer's belief.

The other paper by Hirsch (2016) formalizes the idea that a principal could allow an agent "to implement [the agent's] desired policy even when [the principal] is sure it is wrong, to persuade [the agent] through failure that [the agent] is mistaken." The underlying assumption is that implementation of any policy, even the principal's desired policy, requires the agent's effort, so the principal had better convince the agent to adopt the principal's belief.[4] Behind this idea is the literature on heterogeneous beliefs in organizations (e.g., Van den Steen, 2002, 2010a, 2010b; Che and Kartik, 2009), which demonstrates that heterogeneity encourages players to try to convince others. Again, our mechanism is essentially different. In our model, each player's incentive for experimentation does not come from persuading the other player to make the right decision (which would be the case if the payoff were mutually inclusive) but comes purely from confidence in being proven correct and thereby receiving a mutually exclusive payoff. Moreover, the significance of contingent, mutually exclusive payoffs implies that people shun the notion of being proven incorrect, while the logic about convincing others suggests that significant punishment of the convinced is unnecessary and that people will comfortably admit that they have been convinced. We will use this contrast in the examples to demonstrate our empirical validity relative to alternative explanations.

Apart from these two papers, Cukierman and Tommasi (1998) investigate another similar and intriguing question: how could certain policies "are implemented by 'unlikely' political parties rather than by parties the ideologies of which favor such policies?" For example, as their paper's title reads, "when does it take a Nixon [but not some other politician with a weaker and less persistent anti-Communist record] to go to China?"[5] Their idea is that Nixon has an advantage in transmitting "to the public [his] private information about the relative desirability of" developing United States–China relations and eliciting the public's support for this policy, because "the public has less reason to suspect that [this policy] is proposed solely because of the natural ideological tendencies of [Nixon], i.e., it may be perceived as an objectively motivated policy." A similar argument has also been provided by Cowen and Sutter (1998). With a flavor similar to this "Nixon paradox," in our paper, we show that, when the decision makers care strongly about the contingent, mutually exclusive payoffs, a conservative with an extremely pessimistic view about the new policy, rather than a decision maker with a moderate view, could be more supportive of policy experimentation. This support, however, is motivated by the hope and confidence that the experiment will fail, not by the desire to transmit some private information that the policy will be beneficial to the public.

Our paper also contributes to the literature in several other respects. First, we directly contribute to the literature on strategy choices in large-scale economic reforms, such as transition from a non-market economy (e.g., Lipton and Sachs, 1990; Fernandez and Rodrik, 1991; Murphy et al., 1992; Dewatripont and Roland, 1992a, 1992b, 1995; Coricelli and Milesi-Ferretti, 1993; Gates et al., 1993; Zhao, 1996; Bertocchi and Spagat, 1997; Martinelli and Tommasi, 1997; Wei, 1997; Qian et al., 1999, 2006; Roland, 2002; Rausser et al., 2011, Ch. 18; the survey by Iwasaki and Suzuki, 2016). Roland (2000) recognizes the interaction between politics and aggregate uncertainty about transition as the key to understanding transition and reform strategies, but few studies thoroughly model the interaction.[6] The literature also assumes homogeneous beliefs. We recognize and emphasize the political impact of resolving aggregate uncertainty in the presence of heterogeneous beliefs, which is important in understanding the choice of strategy in the Chinese transition.

Second, the literature on strategic experimentation and policy innovation investigates whether specific decision making environments lead to over- or under-experimentation (e.g., Rose-Ackerman, 1980; Bolton and Harris, 1999; Strumpf, 2002;

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[3] Callander and Hummel (2014) write: "It is striking ...that the choices of real policymakers often stand immune from rational explanation. Even on some of the most important issues of the day, policies are implemented that ostensibly work contrary to the interests of the policymakers who choose them."

[4] Roland (2000, p. 36–37) also hints to apply this idea to the Chinese transition.

[5] This question differs from ours in a subtle way. The question that is more similar to ours would be "when does it take Nixon to go to China [but not some other countries with which he has a more friendly record]?"

[6] For example, in Dewatripont and Roland (1995)'s discussion on strategy choices and sequencing of reforms with homogeneous agents, policymakers simply adopt the politically favorable option after the economic properties of the options are determined by aggregate uncertainty. In the same paper, in the investigation on sequencing of reforms with heterogeneous agents, it is not aggregate but individual uncertainty that determines the optimal sequencing. As a notable exception, Bertocchi and Spagat (1997) recognize that political instability discourages policymakers from resolving aggregate uncertainty through experimentation.

Keller et al., 2005; Keller and Rady, 2010; Volden et al., 2008; Klein, 2013; Millner et al., 2014; Callander and Harstad, 2015; Heidhues et al., 2015). For example, Strulovici (2010) specifies the status quo bias with under-experimentation as "loser trap" and "winner frustration" effects. Roessler et al. (2016) also suggest that "proponents of a moderate reform may fear that it will set the stage for further reforms they would no longer endorse, and thus refuse to support any change in the first place." Their primary focus, however, is when commitment can address this under-experimentation, which is different from ours. More relevantly, Klein and Rady (2011) introduce "negatively correlated bandits," which are mutually exclusive but are not contingent on beliefs, and they focus on common priors and decentralized experimentation. Majumdar and Mukand (2004), Cai and Treisman (2009), Willems (2013), and Dewan and Hortala-Vallve (2014), assuming a single policymaker or homogeneous beliefs, recognize that policy failures could drive voters away.[7] Focusing on a consensus requirement in the presence of heterogeneous beliefs, we address the direct interaction between learning and politics, represented by contingent, mutually exclusive payoffs; show that experimentation can result from extreme disbelief in the wisdom of the experiment; and demonstrate that the heterogeneity of priors determines whether the prospect of a contingent, mutually exclusive payoff will reduce or promote under-experimentation in a consensus environment.

Third, Condorcet (1785)'s jury theorem states that having a larger number of informed decision makers produces better decisions. Numerous studies on decision making and information aggregation in committees investigate the boundary of the theorem given various decision rules (e.g., Austen-Smith and Banks, 1996; Feddersen and Pesendorfer, 1997; McLennan, 1998; Bouton and Castanheira, 2012; Bhattacharya, 2013; Ahn and Oliveros, 2014; Kawamura and Vlaseros, 2016; with a focus on unanimity, Feddersen and Pesendorfer, 1998, 1999; Gerardi, 2000; Visser and Swank, 2007; Bouton et al., Forthcoming; the surveys by Gerling et al., 2005; Li and Suen, 2009). A generalization of our model to *N* players can contribute a counterexample of the theorem to the literature: one more moderate reformer could reject a formerly agreed-on experiment, even of a policy that is indeed effective, because she is not sufficiently confident and would be afraid of being proven incorrect and therefore of being punished. In particular, Levy (2007a,b) discusses reputation concerns of committee members when the result of the committee's decision could show whose vote was correct and whose was wrong, which brings a similar logic to our contingent, mutually exclusive payoffs. Those concerns, however, depend purely on the members' own voting *decisions* (and therefore their *own* priors), while our mutually exclusive payoffs are fundamentally contingent on *all* of the players' *priors*. Also, Levy (2007a,b) focuses on transparency in decision making and rules of voting, which are different foci from ours.[8]

Fourth, the logic that people acquire information when they are confident of receiving the information that will support their position can be found in the literature on strategic information acquisition and persuasion (e.g., Brocas and Carrillo, 2007; Brocas et al., 2012; Gul and Pesendorfer, 2012; Boleslavsky and Cotton, 2013; Alonso and Câmara, 2014; Colombo et al., 2014; Egorov and Sonin, 2014; Felgenhauer and Schulte, 2014). With respect to this literature, our contingent, mutually exclusive payoffs introduce the idea that players' fundamental preferences depend on beliefs. The combination of heterogeneous beliefs and the consensus requirement is also unique.

In the most general sense, our model is linked in several subtle ways to the literature on agent diversity and organizational and economic performance. First, the literature suggests that a team with low work force diversity works well in routine implementation (e.g., Filley et al., 1976; Prat, 2002), while our model suggests that, when aggregate uncertainty exists, low diversity of priors could prevent implementation. Second, Alesina and La Ferrara (2005) identify three channels through which diversity affects economic performance: individual preferences, individual strategies, and production functions. In our model, contingent, mutually exclusive payoffs cause the diversity of priors to enter individual preferences, affect individual strategies, and become an important variable in the function for production of knowledge gained through experimentation. Last but not least, Harrison and Klein (2007) identify the typology of group diversity in the strategic management literature: separation, variety, and disparity. In our paper, variety is the diversity of priors, separation deals with players' preferences about the three options, and disparity is about the consensus requirement, which gives the conservative an advantage over the reformer.

2. The benchmark model with only mutually inclusive payoff

There are two players coming to a discussion about whether and how the organization should adopt a policy. The policy can be good or bad, which is determined by nature. The players do not know whether the policy is good, but they have their own priors: one player believes the policy has a probability p of being good, while the other believes the probability is q. We assume $0 \leq q < p \leq 1$, and therefore we label the player with the larger prior the *reformer*, and the other the *conservative*.

There are three options for the decision: adopting the policy in a Big Bang approach, adopting it in an experimental approach, or doing nothing. The first two approaches require the agreement of both players, while each player is free to choose the do-nothing option (i.e., "do nothing" is the outcome if the players cannot agree). The solution concept that we use is the *core* of a cooperative game. The Big Bang approach will be in the core if the following two conditions are satisfied. First, both players prefer the Big Bang over doing nothing. This condition is intuitive, because, if this condition does not

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[7] Majumdar and Mukand (2004), Willems (2013), and Dewan and Hortala-Vallve (2014) focus on the feature of policy decisions to signal politicians' competence.

[8] Midjord et al. (2015) consider a negative disesteem payoff in the spirit of Levy (2007a,b).

Table 1
Expected mutually inclusive payoff from the three options.

Player	Big Bang approach	Experimental approach	Doing nothing
Reformer	$pa_r - (1-p)b_r$	$p(\rho a_r + \delta a_r) - (1-p)\rho b_r$	0
Conservative	$qa_c - (1-q)b_c$	$q(\rho a_c + \delta a_c) - (1-q)\rho b_c$	0

hold, the player who prefers doing nothing over the Big Bang will veto the Big Bang. Second, compared with the Big Bang approach, the experimental approach will not be able to generate a Pareto improvement for the players. This condition is also intuitive, because, if this condition does not hold, the two players will move away from the Big Bang approach (to the experimental approach). Similarly, the experimental approach will be in the core under the two corresponding conditions that both players prefer the experimental approach over doing nothing and that the Big Bang will not generate a Pareto improvement for both players. It is also possible that the Big Bang and the experimental approaches are both in the core. This scenario will happen if both players prefer these two approaches over doing nothing, and if one of them prefers the Big Bang approach while the other prefers experimentation. When neither the Big Bang approach nor the experimental approach is in the core, the core will contain only the do-nothing option, and no reform will happen.

Before introducing the payoff structure, we remark here on our use of the cooperative-game approach. The results derived from this approach can also be achieved by some non-cooperative games. For the case where the core contains both the Big Bang and the experimental approaches, a non-cooperative approach would allow us to refine the multiple solutions into a unique solution, but this refinement would depend critically on the specific extensive form of the non-cooperative game, e.g., whether the conservative or the reformer is the first-mover. Therefore, we adopt the cooperative-game approach in the main text for theoretical robustness, and we present an example of equivalent non-cooperative games in Appendix A.1.

We set the payoff structure as follows:

The Big Bang approach. If the adoption succeeds, then each player gets $a_i > 0$, where for the reformer $i = r$ and for the conservative $i = c$; otherwise, each player gets $-b_i < 0$.

The experimental approach. The policy is first implemented on a small scale ρ, where $0 < \rho < 1$. If the experiment's result shows that the policy is good, then the two players will automatically generalize the policy to the rest of the organization, and will get the payoff with a time discount. Therefore, each player will get $\rho a_i + \delta a_i$, where $\rho < \rho + \delta < 1$.[9] If the experiment's result shows the policy is bad, then they stop the adoption, and each player gets $-\rho b_i$.

Doing nothing. The policy is not adopted, and both players get 0 as the default payoff.

We call this payoff structure *mutually inclusive payoff,* because, after the policy turns out to be good or bad, the two players win and get a positive payoff, or lose and get a negative payoff, always together. We will contrast this payoff structure with contingent, mutually exclusive payoffs later. We assume the players maximize their own expected payoff, and Table 1 shows their expected payoffs from the three options.[10]

So far, we have introduced only different priors and the consensus requirement, the first two key assumptions of our model. We have not introduced the last key assumption, the contingent, mutually exclusive payoffs. To appreciate the role of the contingent, mutually exclusive payoffs, we will first solve the model with only mutually inclusive payoff in the next section as a benchmark.

3. Analysis of the benchmark model

Based on the payoff structure, the trade-off between a Big Bang approach and an experimental approach is that the experimental approach enjoys the option of stopping the adoption of a possibly bad policy, but delays the adoption of a possibly good policy. For the reformer, the option value of the experimental approach (compared with the Big Bang approach) is $(1-p)(1-\rho)b_r$, which is decreasing in p, while its delay cost is $p(1-\rho-\delta)a_r$, which is increasing in p. For the conservative, a similar argument holds. Therefore, for each of the players, a higher prior makes the Big Bang approach more appealing than the experimental approach.

The prior also determines the trade-off between doing nothing, on the one hand, and agreeing to pursue either of the reform approaches, on the other. A higher prior increases the expected payoffs of both approaches, so that doing something will be more likely to beat doing nothing.

We further illustrate the dependence of the trade-offs on the prior in Fig. 1a and b, where we plot the two players' own expected payoffs from the three options as functions of their own prior. In both of the figures, the do-nothing option is

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[9] We simplify the idea that $\delta = \frac{1}{1+r}(1-\rho)$, where r is the discount rate.

[10] For simplicity, we set the payoffs as a linear function in $s \in \{0, \rho, 1\}$, the scale of the adoption. More generally, we can also set the payoff structure in a nonlinear way, as follows. When the adoption follows the Big Bang approach ($s = 1$), the expected mutually inclusive payoff for the reformer is $pa_r(1) - (1-p)b_r(1)$; when the adoption follows the experimental approach ($s = \rho$), the expected payoff for the reformer is $p[a_r(\rho) + \frac{1}{1+r}a_r(1-\rho)] - (1-p)b_r(\rho)$; when there is no adoption at all ($s = 0$), the payoff for the reformer is 0. For the conservative, similar payoffs follow. Also assume that $a_r(s)$, $a_c(s)$, $b_r(s)$, and $b_c(s)$ are all increasing and are equal to 0 when $s = 0$. This generalization does not affect our results.
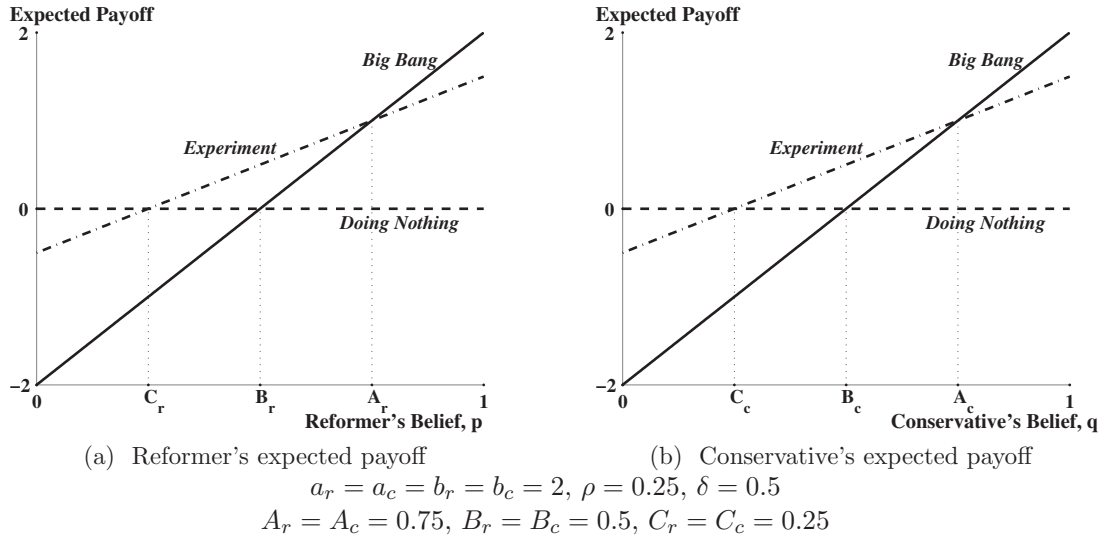
Fig. 1. An example of expected payoffs in the model with only mutually inclusive payoff.

always expected to generate the default zero payoff, while the expected payoffs from the experimental and the Big Bang approaches are increasing in the prior and cross the horizontal, zero-payoff line from below. For the reformer, we define the three break-even priors A_r, B_r, and C_r by

$$A_r = \frac{(1-\rho)b_r}{(1-\rho)a_r - \delta a_r + (1-\rho)b_r}, \quad B_r = \frac{b_r}{a_r + b_r}, \quad C_r = \frac{\rho b_r}{\rho a_r + \delta a_r + \rho b_r}. \tag{1}$$

At these points, the reformer is indifferent among the three trade-offs: the Big Bang approach versus the experimental approach (A_r), the Big Bang approach versus doing nothing (B_r), and the experimental approach versus doing nothing (C_r).[11] It is also obvious that $A_r > B_r > C_r$. Therefore, as illustrated in Fig. 1a, if the reformer is sufficiently pessimistic about the new policy ($0 \leq p < C_r$), she will prefer the do-nothing option; if she strongly believes in the new policy ($A_r < p \leq 1$), she will prefer the Bing Bang approach; only when she has a moderate belief ($C_r < p < A_r$), she will prefer the experimental approach.

Similarly, we define the three indifference values of the conservative's prior as A_c, B_c, and C_c, and Fig. 1b illustrates that the conservative's preference among the three options has the same pattern as the reformer's. Given this analysis, we proceed with Proposition 1, the main result of this section.[12]

Proposition 1. *Assume that the only payoff from adopting the policy is mutually inclusive. Then the following two statements are true:*

  i) *If the conservative strongly believes that the policy is a bad idea, then neither the Big Bang approach nor the experimental approach will be adopted, no matter how strongly the reformer believes in the policy.*
  ii) *The experimental approach will not be adopted unless the conservative neither strongly believes in the policy nor strongly believes that the policy is a bad idea.*

Mathematically, if there is only mutually inclusive payoff from adopting the policy, then the following two statements are true:

  i) *If $0 \leq q < C_c$, then for any p such that $q < p \leq 1$, the policy will not be adopted.*
  ii) *The experimental approach will not be adopted unless $C_c < q < A_c$.*

Appendix A.2 proves Proposition 1. The intuition of Proposition 1 is as follows. The key is the consensus requirement for the adoption of either approach. For Result i), if the conservative sufficiently disagrees with the policy ($0 \leq q < C_c$), then she prefers doing nothing over both the Big Bang approach and the experimental approach. If so, no matter how strongly the reformer believes in the policy and no matter which option the reformer prefers, the conservative will always veto the policy adoption by withholding consensus (i.e., choosing to do nothing). For Result ii), on the one hand, the experimental approach could be adopted if the conservative does not veto it, i.e., does not exercise her choice to do nothing. In this case, the conservative does not strongly dislike the policy ($C_c < q \leq 1$). On the other hand, the experimental approach will not be

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[11] If $p > A_r$, the reformer will prefer the Big Bang approach over the experimental approach. If $p > B_r$, the reformer will prefer the Big Bang approach over doing nothing. If $p > C_r$, the reformer will prefer the experimental approach over doing nothing.

[12] For simplicity, we consider only the cases in which p and q are not equal to any of the indifference values.

$$a_r = a_c = b_r = b_c = 2, \; \rho = 0.25, \; \delta = 0.5$$
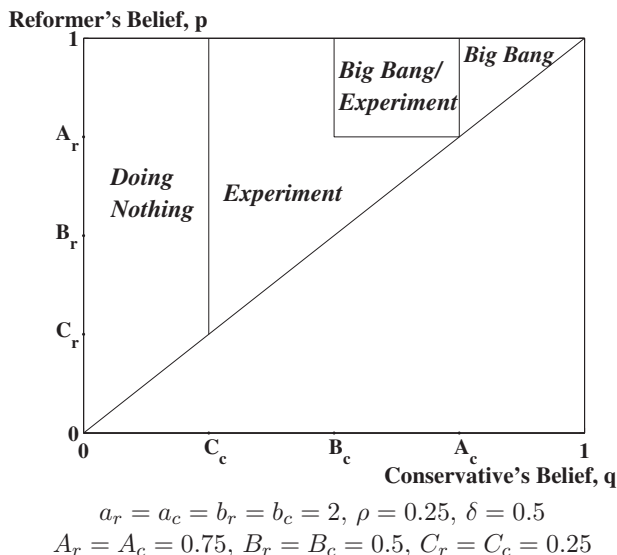$$A_r = A_c = 0.75, \; B_r = B_c = 0.5, \; C_r = C_c = 0.25$$

Fig. 2. An example of the model with only mutually inclusive payoff.

adopted if both players expect higher payoffs in an agreement for a Big Bang approach, in which case even the conservative strongly believes in the policy ($A_c < q \leq 1$).

Fig. 2 illustrates Proposition 1. Each point (p, q) represents the case in which the reformer and the conservative respectively have priors p and q. Because we assume that $0 \leq q < p \leq 1$, we consider only the upper-left triangle in the unit square. As Proposition 1 states, Fig. 2 indicates that the two players will not agree to the adoption of any policy if the conservative is sufficiently conservative ($0 \leq q < C_c$), and that the experimental approach is possible only if the conservative has a moderate prior ($C_c < q < A_c$).[13]

Fig. 2 also shows that "Doing Nothing" occupies the left-top corner of the unit square, while "Experiment" occupies the area where p is slightly higher than B_r and q is slightly lower than B_c. Here, the take-home message of this section emerges: when payoffs are mutually inclusive, diametrically opposite beliefs are associated with doing nothing, while moderate or slightly different priors are associated with the experimental approach.

4. Contingent, mutually exclusive payoffs

Keeping the mutually inclusive payoff, we now allow the decision makers to consider a second payoff structure, where the experiment's result shows not only whether the policy is good, but also which player was on the correct side. Now, the correct side will be rewarded while the other will be punished.

The experimental approach. If the experiment's result shows the policy is good/bad, then the player with the higher/lower prior gets e, while the other player gets $-d$, where $d > 0$ and $e > 0$.

We call this payoff structure *contingent, mutually exclusive payoffs,* sometimes abbreviated as mutually exclusive payoffs. By "mutually exclusive," we mean that, if one player wins, the other must lose. By "contingent," we mean that the allocation of the reward and punishment depends on the relative position of the priors *and* on the result of the experiment.

We assume the players value these mutually exclusive payoffs over the mutually inclusive payoff, with a weight $\beta \in [0, \infty]$.

Intuitively, the magnitude of the reward and punishment should also depend on the degree of difference between the players' priors about whether the new policy is good: when the priors are almost the same, it is difficult to distinguish who was correct and who was incorrect after the result of the experiment is observed, and therefore the magnitude of the reward and punishment are likely to be small; when the priors are significantly different, however, it is much easier to see who was correct and who was incorrect, and the corresponding reward or punishment is likely to be more substantial. We model this dependency by assuming that mutually exclusive payoffs will exist (and the players will take them into consideration) if and only if the players have some "fundamental disagreement," by which we mean that, when considering only the mutually inclusive payoff, the players disagree about whether the Big Bang is more appealing than the do-nothing option ($B_r < p \leq 1$ and $0 \leq q < B_c$). In this case, we say that the mutually exclusive payoffs are "effective," i.e., substantial

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[13] Another observation from Fig. 2 is that the Big Bang approach will not be adopted unless the reformer strongly believes in the policy ($A_r < p \leq 1$) and the conservative will not veto it with doing nothing ($B_c < q \leq 1$).

Table 2
Expected mutually inclusive and weighted mutually exclusive payoffs from the three options.

Player	Big Bang approach	Experimental approach	Doing nothing
Reformer	$pa_r - (1-p)b_r$	$p[\rho a_r + \delta a_r + \beta f(p,q)e] - (1-p)[\rho b_r + \beta f(p,q)d]$	0
Conservative	$qa_c - (1-q)b_c$	$q[\rho a_c + \delta a_c - \beta f(p,q)d] - (1-q)[\rho b_c - \beta f(p,q)e]$	0

$f(p,q) = 1$ if $p \in (B_r, 1]$ and $q \in [0, B_c)$; otherwise $f(p,q) = 0$.
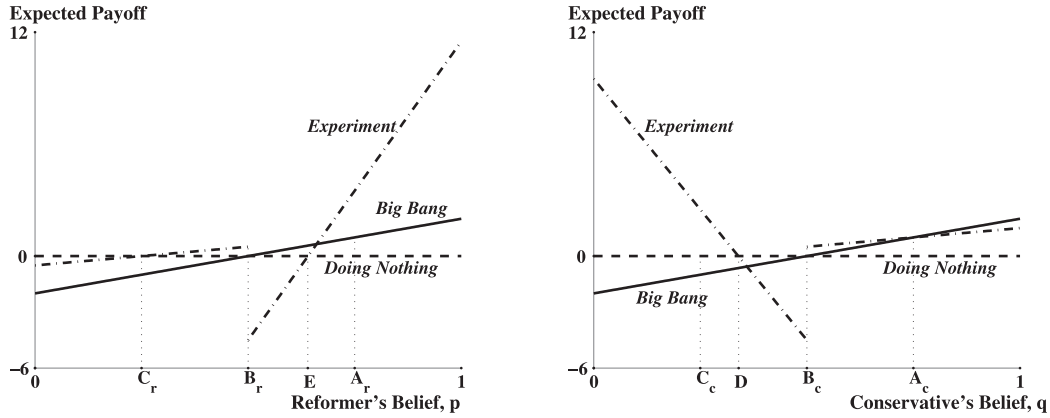
(a) Reformer's expected payoff given $0 \leq q < B_c$ (b) Conservative's expected payoff given $B_r < p \leq 1$
$a_r = a_c = b_r = b_c = 2,\ e = 1,\ d = 2,\ \rho = 0.25,\ \delta = 0.50,\ \beta = 10$
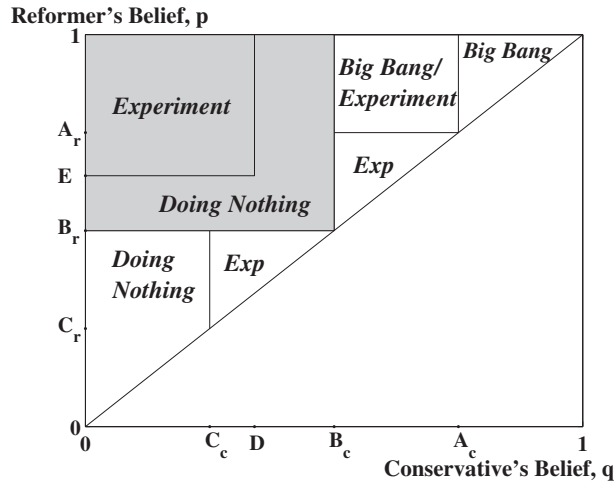$A_r = A_c = 0.75,\ B_r = B_c = 0.5,\ C_r = C_c = 0.25,\ D = 0.34,\ E = 0.64$

Fig. 3. Expected mutually inclusive and weighted mutually exclusive payoffs in the typical case with large β.

enough to affect the players' considerations. In other words, the mutually exclusive payoffs are $f(p,q)e$ and $f(p,q)d$, where $f(p,q)$ is an indicator function that will be equal to one if and only if $B_r < p \leq 1$ and $0 \leq q < B_c$. This assumption, which makes the magnitude of the mutually exclusive payoffs depend on the degree of difference between the priors in a very simplistic way, does not drive our main result and will generate richer results and sharper graphs.

The expected mutually inclusive and weighted mutually exclusive payoffs for the two players from all three options are shown in Table 2. Fig. 3a plots the expected payoffs for the reformer, given that β is sufficiently large and assuming that $0 \leq q < B_c$, i.e., assuming that the conservative would prefer doing nothing over the Big Bang approach if only the mutually inclusive payoff were considered. Because the mutually exclusive payoffs do not apply to the do-nothing approach or the Big Bang approach, and because these payoffs are not effective unless the players have a fundamental disagreement, Fig. 3a differs from Fig. 1a only in the expected payoff from the experimental approach when $B_r < p \leq 1$. That said, in Fig. 3a, the expected payoff from the experimental approach when $B_r < p \leq 1$ is still increasing in the reformer's prior, just as in Fig. 1a. This is the case because the reformer will get a positive mutually exclusive payoff if and only if the experiment succeeds. In other words, for the reformer, the mutually exclusive and mutually inclusive payoffs always have the same sign.

Fig. 3b plots the expected payoffs for the conservative, given that β is sufficiently large and assuming that $B_r < p \leq 1$, i.e., assuming that the reformer would prefer the Big Bang approach over doing nothing if only the mutually inclusive payoff were considered. Following the same logic as above, Fig. 3b differs from Fig. 1b only in the expected payoff from the experimental approach when $0 \leq q < B_c$. In this part, however, the expected payoff from the experimental approach becomes decreasing in the conservative's prior. This change comes directly from the introduction of the mutually exclusive payoffs and the large β: if the conservative holds a more pessimistic belief about the new policy, she will be more confident that the experiment will fail and that she will win the positive mutually exclusive payoff; this consideration will dominate the consideration of a mutually inclusive payoff when she cares strongly about the mutually exclusive payoff, i.e., when β is sufficiently large.

Given the impacts of the mutually exclusive payoffs on the players' expected payoffs from experimentation, we now focus on the case in which mutually exclusive payoffs are effective, i.e., when the conservative would prefer doing nothing over the Big Bang approach while the reformer would prefer the Big Bang approach to doing nothing if the players considered only the mutually inclusive payoff. First, observe that mutually exclusive payoffs only affect the experimental versus Big Bang trade-off and the experimental versus doing nothing trade-off, but not the Big Bang versus doing nothing trade-off, so the conservative still always prefers doing nothing over the Big Bang approach, just as in the model with only mutually inclusive payoffs. Therefore, the Big Bang approach will still not be adopted. As a result, we care only about the effect of the mutually exclusive payoffs on the trade-off between the experimental approach and doing nothing. As indicated in Fig. 3b and a, for the conservative and the reformer, we define as follows the break-even priors D (for the conservative) and E

$a_r = a_c = b_r = b_c = 2, \ e = 1, \ d = 2, \ \rho = 0.25, \ \delta = 0.50, \ \beta = 10$
$A_r = A_c = 0.75, \ B_r = B_c = 0.5, \ C_r = C_c = 0.25, \ D = 0.34, \ E = 0.64$

Fig. 4. The typical case with large β.

(for the reformer), with which they would be indifferent between an experimental approach and doing nothing when the mutually exclusive payoffs are effective:

$$D = \frac{\rho b_c - \beta e}{\rho a_c + \delta a_c + \rho b_c - \beta (e+d)}, \qquad E = \frac{\rho b_r + \beta d}{\rho a_r + \delta a_r + \rho b_r + \beta (e+d)}. \tag{2}$$

With the two newly-introduced indifference priors, we proceed with Proposition 2, the main result of this section and this paper.[14]

Proposition 2. *Assume the two players have different preferences between the Big Bang approach and doing nothing when considering only the mutually inclusive payoff. Then contingent, mutually exclusive payoffs are effective. Further assume the players care strongly about these contingent, mutually exclusive payoffs. Then the following two statements are true:*

i) *If the conservative holds a sufficiently strong disbelief in the policy, while the reformer sufficiently believes in the policy, then the experimental approach will be adopted.*
ii) *Otherwise, the policy will not be adopted.*

Mathematically and more precisely, assume $B_r < p \leq 1$ and $0 \leq q < B_c$. Then $f(p,q) = 1$. Further assume $\beta > \max\{\frac{\rho(a_c+b_c)+\delta a_c}{e+d}, \frac{\rho b_c}{e}\}$. Then the following two statements are true:

i) *If $0 \leq q < \min\{D, B_c\}$ and $\max\{B_r, E\} < p \leq 1$, then the experimental approach will be adopted.*
ii) *If $D < q < B_c$ or $B_r < p < E$, then the policy will not be adopted.*

Appendix A.3 proves Proposition 2. The intuition of Proposition 2 is as follows. The key is still the requirement of consensus for adopting either approach. When the mutually exclusive payoffs are effective, the conservative always prefers doing nothing over a Big Bang approach, so the Big Bang approach will not be adopted. If the conservative sufficiently cares about the mutually exclusive payoffs ($\beta > \max\{\frac{\rho(a_c+b_c)+\delta a_c}{e+d}, \frac{\rho b_c}{e}\}$), then the mutually exclusive-payoff consideration will dominate her mutually inclusive-payoff consideration about the experimental approach. More specifically, she will prefer a failed experiment to *both* of a successful experiment ($-\rho b_c + \beta e > \rho a_c + \delta a_c - \beta d$) and doing nothing ($-\rho b_c + \beta e > 0$). In this case, on the one hand, if the conservative holds a sufficiently strong disbelief in the policy ($0 \leq q < \min\{D, B_c\}$), then she will be confident enough of seeing a failed experiment if the experimental approach is adopted, and thus being proven correct. With this consideration in mind, she will prefer the experimental approach over doing nothing. On the other hand, the experimental approach will still not be adopted if the reformer does not sufficiently believe in the policy ($B_r < p < E$), since she will be afraid of losing too much in the "political gamble" in the form of policy experimentation, and the expected loss will induce her to prefer doing nothing over the experimental approach. Therefore, the experimental approach will be adopted *only* if the players have diametrically opposite priors; otherwise, the policy will not be adopted.

Fig. 4 illustrates Proposition 2. The mutually exclusive payoffs are effective only in the shaded area. In this area, as Proposition 4 states, the experimental approach will be adopted if the players hold diametrically opposite beliefs ($0 \leq q <$

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[14] For simplicity, we only consider the cases in which p and q are not equal to any of the indifference priors.

min$\{D, B_c\}$ and max$\{B_r, E\} < p \leq 1$); the policy will not be adopted if one of the player's prior is not sufficiently extreme ($D < q < B_c$ or $B_r < p < E$). In other words, "Experiment" occupies the left-top corner of both the shaded area and the unit square, while "Doing Nothing" occupies the right-bottom corner of the shaded area, which is the area where p is slightly higher than B_r and q is slightly lower than B_c. In contrast to Fig. 2, Fig. 4 shows that introducing contingent, mutually exclusive payoffs reverses the relationship between priors and the experimental approach: extreme, diametrically opposite beliefs are associated with the experimental approach, while moderate, slightly different priors are associated with doing nothing if the mutually exclusive payoffs are effective and if the players care strongly about these payoffs.

One way to appreciate Proposition 2 is to observe the relationship between the conservative's prior, q, and the model solution, given an optimistic reformer ($E < p \leq 1$). In Fig. 2, as q increases from 0 to 1, the model solution evolves from doing nothing, to the experimental approach, and ends up with the Big Bang approach. This conventional monotonicity is broken up in Fig. 4: the model solution starts from the experimental approach, then turns into doing nothing, and later goes back to the experimental approach or the Big Bang approach. A similar nonmonotonic relation also exists between the reformer's prior, p, and the model solution, given a moderate conservative ($C_c < q < D$), as p increases from (C_r, B_r) to 1.

Another way to understand Proposition 2 is to recognize the difference between cooperative *behavior* and cooperative *motives.* In the shaded area labelled "Experiment" in Fig. 4 (corresponding to Statement i in Proposition 2), the players do cooperate, in the sense that they reach an agreement in experimentation without unilaterally exercising their veto power. This cooperative behavior, however, is driven by non-cooperative motives, i.e., the desire to be proven correct by the result of the experiment and to gain positive mutually exclusive payoffs. In contrast, in the areas in Fig. 2 that are not occupied by "Doing Nothing", the players also cooperate, but here cooperation takes the form of agreeing to adopt a reform, and this cooperative behavior is driven purely by cooperative motives, i.e., the mutually inclusive payoff.

A little discussion is needed about the role of the unanimity assumption in our results. On the one hand, this assumption gives veto power to the conservative. This veto power is essential for the potential for gridlock, in which an extreme conservative who considers only a mutually inclusive payoff will always veto any reform regardless of the reformer's belief, as shown in Proposition 1. As shown by the comparison between Propositions 1 and 2, this potential gridlock is instrumental in illustrating the consequence of the mutually exclusive payoffs, in that confidence in being proven correct and winning the mutually exclusive payoff can drive the conservative not to use the veto power but instead to agree with the reformer on experimentation. Therefore, any decision rule that grants veto power to the conservative, e.g., a majority rule when the conservative is the majority, can help the illustration.

On the other hand, the unanimity assumption also provides the veto power to the reformer, protecting her from the adoption of reforms that she does not like. For example, in Fig. 4, if $0 \leq p < C_c$ and $B_r < p < E$, the conservative will prefer experimentation over doing nothing, while the reformer will prefer doing nothing because of her lack of confidence in the success of the experiment. The reformer will then veto experimentation. This potential "conservative" behavior of the reformer, however, will not be observed under any decision rule that grants the veto power only to the conservative but not to the reformer. For example, under a majority rule when the conservative is the majority, if $0 \leq p < C_c$ and $B_r < p < E$, the reformer will have no choice but to watch the conservative push through the experiment.

It also is necessary to emphasize that Proposition 2 depends on the condition that the players care strongly about the mutually exclusive payoffs ($\beta > \max\{\frac{\rho(a_c+b_c)+\delta a_c}{e+d}, \frac{\rho b_c}{e}\}$). If the players cared little about the mutually exclusive payoffs (i.e., if β were small), we would expect the solution pattern of the model to be similar to the case without mutually exclusive payoffs, i.e., Fig. 2. Only when the players care strongly about the mutually exclusive payoffs will they consider the experimental approach as an opportunity to grab the reward from being proven correct. To further demonstrate the mechanism behind Proposition 2, we present comparative statics of the model in Appendix A.4.

As space is limited, we leave an extension of the model to appendices. Appendix A.5 extends the mutually exclusive payoffs to the Big Bang approach and discusses the implications of our results for the relationship between the magnitude of the extended mutually exclusive payoffs and the scale of policy implementation.

To conclude this section, we emphasize that in our model, given *a sufficiently small q* ($0 \leq q < \min\{D, C_c\}$) and *a sufficiently large β* ($\beta > \max\{\frac{\rho(a_c+b_c)+\delta a_c}{e+d}, \frac{\rho b_c}{e}\}$), the adoption of an experimental approach comes from the interaction between different priors and the contingent, mutually exclusive payoffs:

Similar priors with only mutually inclusive payoff. If $0 \leq p < C_r$ and $0 \leq q < \min\{D, C_c\}$, then as shown in Fig. 2, both players prefer doing nothing, and there is no policy adoption.

Different priors with only mutually inclusive payoff. If $C_r < p < 1$ and $0 \leq q < \min\{D, C_c\}$, then as shown in Fig. 2, the conservative vetoes the experimental approach (and the Big Bang approach), and there is no policy adoption.

Similar priors with contingent, mutually exclusive payoffs. As shown in Fig. 4, there are two cases: 1) if $0 \leq p < B_r$ and $0 \leq q < \min\{D, C_c\}$, then the mutually exclusive payoffs are ineffective; 2) if $B_r < p < E$ and $0 \leq q < \min\{D, C_c\}$, then the mutually exclusive payoffs are effective, and the conservative prefers the experimental approach over doing nothing, but the reformer is afraid of losing too much politically during the experimental approach. In both cases, there is still no policy adoption.

Different priors with contingent, mutually exclusive payoffs. As shown in Fig. 4, the experimental approach will be adopted only if the priors are diametrically opposite (max$\{B_r, E\} < p \leq 1$ and $0 \leq q < \min\{D, C_c\}$) and contingent, mutually exclusive

payoffs exist. In this case, the adoption of the experimental approach results from *both* players' confidence in being proven correct by the experiment's result and thus being rewarded.

5. A perspective of organizational welfare

As shown in our main result, serious consideration of the political implications of experimental learning will induce experimentation when the priors are diametrically opposite and will shut down any reform when the priors are slightly different. Are these outcomes desirable from the perspective of the organization, and how should an "organizational planner" make use of the political consideration? To answer these questions, in this section, we compare 1) the collective decision in the benchmark model, 2) the collective decision in the model with mutually exclusive payoffs, and 3) the decision that maximizes organizational welfare, which is defined as the total value of the mutually inclusive payoff.

For simplicity, we assume that the mutually inclusive payoff is symmetric across the players, which means $a_r = a_c \equiv a$ and $b_r = b_c \equiv b$. Given this symmetry, there is an equivalence between the organizational planner who maximizes the *sum of the players' expectations* of the mutually inclusive payoff given the players' priors, p and q, and the organizational planner who maximizes *her expectation of the sum* of the players' mutually inclusive payoff and believes that the probability that the policy is good is $\pi \equiv \frac{p+q}{2}$. In other words, given any p and q, the two organizational planners will always make the same choice among the Big Bang approach, the experimental approach, and doing nothing. We therefore consider these two organizational planners together as just one planner.

We can then identify that this organizational planner will prefer the Big Bang approach to the experimental approach if and only if

$$\pi \equiv \frac{p+q}{2} > A \equiv \frac{(1-\rho)b}{(1-\rho)a - \delta a + (1-\rho)b}. \tag{3}$$

She will prefer the Big Bang approach to doing nothing if and only if

$$\pi \equiv \frac{p+q}{2} > B \equiv \frac{b}{a+b}. \tag{4}$$

She will prefer the experimental approach to doing nothing if and only if

$$\pi \equiv \frac{p+q}{2} > C \equiv \frac{\rho b}{\rho a + \delta a + \rho b}. \tag{5}$$

Also note $C < B < A$, so she will adopt the Big Bang approach if $\pi > A$ and the experimental approach if $C < \pi < A$ and do nothing if $\pi < C$.[15]

Fig. 5 shows the decision of the organizational planner using the same parameters as in Figs. 2 and 4, and the shaded area corresponds to the shaded area in Fig. 4 where the players care strongly about the mutually exclusive payoffs. Comparing Figs. 2 and 5, we see that the consensus requirement creates under-experimentation when the priors are diametrically opposite. This is the case because, when p and q converge to 1 and 0, respectively, the organizational planner will choose the experimental approach while the conservative who only considers a mutually inclusive payoff will veto any reform. The consensus requirement does not cause under-experimentation when the priors are slightly different: this is the case because, when p is slightly higher than B and q is slightly lower than B, the choice of the organizational planner and the agreement between the players are the same – they would like to experiment. Linking Fig. 4 to the comparison, we find that introducing serious concerns about the mutually exclusive payoffs reduces the former under-experimentation when the priors are diametrically opposite, but creates under-experimentation when the priors are slightly different.[16]

To summarize, given the consensus requirement, whether serious consideration of the political implications of experimental learning is desirable to the organization depends on the heterogeneity of beliefs. It is desirable when the beliefs are diametrically opposite, but not appealing when the beliefs are slightly different.

6. Endogenous contingent, mutually exclusive payoffs

One may argue that, although the difference in priors is common knowledge among the players, if none of them decides to disclose this difference to outsiders before experimentation, the result of the experiment might not be able to generate significant mutually exclusive payoffs. Following this logic, in this section, we endogenize the mutually exclusive payoffs by allowing the players to decide whether to disclose or conceal the difference in their priors so that they can create or mute the mutually exclusive payoffs.

The setting of the extension is as follows. We assume that there are two stages in the decision of whether and how to adopt the new policy. In the first stage, the two players determine together whether to disclose their beliefs to outsiders. We assume that any disclosure is costless and truthful, and that, if at least one of the players discloses, the outsiders will

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[15] We still ignore the break-even cases for simplicity.

[16] For aesthetic simplicity, the specification in Fig. 5 makes $B = 2C = 2A - 1$, which is not universally true. The discussion always holds, however, because $C < B < A$.
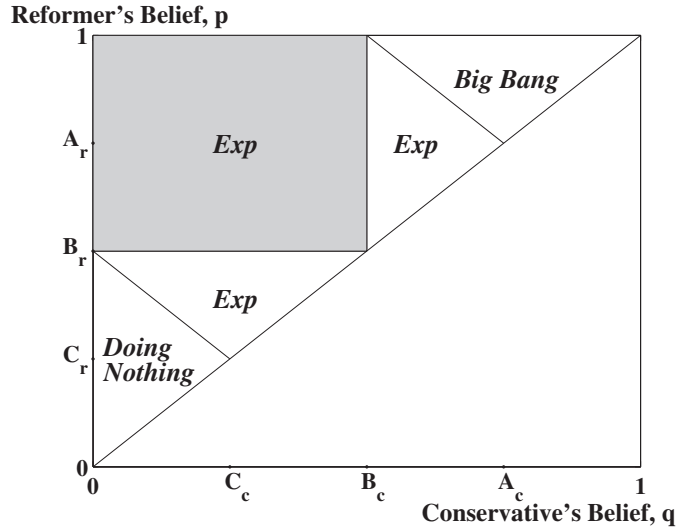
$$a_r = a_c \equiv a = b_r = b_c \equiv b = 2, \; \rho = 0.25, \; \delta = 0.50$$
$$A_r = A_c \equiv A = 0.75, \; B_r = B_c \equiv B = 0.5, \; C_r = C_c \equiv C = 0.25$$

Fig. 5. An example of the decision of the organizational planner.

Table 3
Expected payoffs from the three options given the first-stage outcome.

Player	Big Bang approach	Experimental approach	Doing nothing
Reformer	$pa_r - (1-p)b_r$	$p[\rho a_r + \delta a_r + \beta f(p,q,v)e] - (1-p)[\rho b_r + \beta f(p,q,v)d]$	0
Conservative	$qa_c - (1-q)b_c$	$q[\rho a_c + \delta a_c - \beta f(p,q,v)d] - (1-q)[\rho b_c - \beta f(p,q,v)e]$	0

$v = 1$ if at least one of the players has disclosed the beliefs at the first stage; otherwise $v = 0$. $f(p,q,v) = 1$ if $B_r < p \le 1$, $0 \le q < B_c$, and $v = 1$; otherwise $f(p,q,v) = 0$.

know the beliefs of the two players. As before, we still adopt the *core* as the solution concept for the first stage: the tacit agreement of no disclosure will be in the core if and only if neither of them prefers disclosing over not disclosing, while the situation in which someone discloses will be in the core if and only if at least one of the players prefers disclosing over not disclosing.[17]

The second stage is assumed to depend on the outcome of the first stage, as follows. If neither of the players discloses the beliefs, then the second stage is exactly the same as our benchmark model in Section 2, i.e., only the mutually inclusive payoff exists and no mutually exclusive payoff exists. If, however, at least one of the players discloses the beliefs, then the second stage is exactly the same as the model in Section 4, i.e., the mutually exclusive payoffs will exist in addition to the mutually inclusive payoff if and only if the players have a fundamental disagreement. In other words, the function indicating the effectiveness of the mutually exclusive payoffs, $f(p, q)$, now becomes $f(p, q, v)$, where v is an endogenous variable denoting whether the players have "voiced up" at the first stage: $v = 1$ if at least one of the players has disclosed the beliefs, and $v = 0$ otherwise. The indicator function, $f(p, q, v)$, will then be equal to one if and only if $B_r < p \le 1$, $0 \le q < B_c$, and $v = 1$.

The expected payoffs from the three options in this extension are then presented in Table 3. It is clear that, if neither player has disclosed in the first stage (i.e., if $v = 0$), then Table 3 will degenerate into Table 1, and, if at least one of the players has disclosed (i.e., if $v = 1$), then Table 3 will degenerate into Table 2.

This extension can be solved by backward induction. Given the first-stage outcome, i.e., either none of the players has disclosed or at least one of them has disclosed, we can find the solution of the second stage as in Section 3 (if neither one has disclosed) or Section 4 (if at least one has disclosed). Because these second-stage solutions depend on the first-stage outcome, we can know whether each player would like to have the priors disclosed in the first stage based on the expected payoffs in the second stage. The solution of the first stage can then be found.

When the players do not have a fundamental disagreement, i.e., when $0 \le p \le B_r$ or $B_c \le q \le 1$, no matter whether someone has disclosed in the first stage, mutually exclusive payoffs will not exist. Therefore, in this case, the payoff structure

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[17] For simplicity, we ignore the indifference cases.
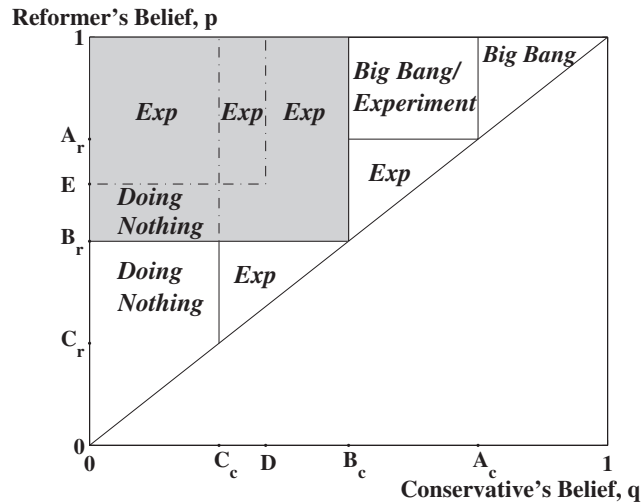
$$a_r = a_c = b_r = b_c = 2, \ e = 1, \ d = 2, \ \rho = 0.25, \ \delta = 0.50, \ \beta = 10$$
$$A_r = A_c = 0.75, \ B_r = B_c = 0.5, \ C_r = C_c = 0.25, \ D = 0.34, \ E = 0.64$$

Fig. 6. An example of the model with endogenous contingent, mutually exclusive payoffs.

of the second stage will not depend on the first-stage outcome, so the two players are indifferent between disclosing and not disclosing in the first stage.

Now we analyze the case in which the players do have a fundamental disagreement, i.e., $B_r < p \leq 1$ and $0 \leq q < B_c$, so that the mutually exclusive payoff will exist in the second stage if someone has disclosed in the first stage. To be comparable with Proposition 2, we also assume that β is sufficiently large ($\beta > \max\{\frac{\rho(a_c+b_c)+\delta a_c}{e+d}, \frac{\rho b_c}{e}\}$). We present some of the results in Proposition 3.

Proposition 3. *Assume the two players have different preferences between the Big Bang approach and doing nothing when considering only the mutually inclusive payoff. Then contingent, mutually exclusive payoffs will be effective if and only if, in the first stage, at least one of the players has disclosed their priors to outsiders. Further assume the players care strongly about these contingent, mutually exclusive payoffs if the payoffs are effective. Then the following two statements are true:*

i) *If the conservative sufficiently disbelieves in the policy while the reformer sufficiently believes in the policy, then the players' priors will be disclosed, the contingent, mutually exclusive payoffs will be effective, and the experimental approach will be adopted.*

ii) *If a) the conservative does not strongly disbelieve in the policy while the reformer does not sufficiently believe in the policy, or b) the conservative's level of disbelief in the policy is sufficiently low, regardless of the reformer's belief, then neither of the players will disclose their priors, and the contingent, mutually exclusive payoffs will not be effective, but the experimental approach will still be adopted.*

Mathematically and more precisely, assume $B_r < p \leq 1$ and $0 \leq q < B_c$. Further, assume $\beta > \max\{\frac{\rho(a_c+b_c)+\delta a_c}{e+d}, \frac{\rho b_c}{e}\}$. Then, the following two statements are true:

i) *If $0 \leq q \leq \min\{D, C_c\}$ and $\max\{B_r, E\} < p \leq 1$, then $v = 1$ and the experimental approach will be adopted.*

ii) *If $C_c < q < D$ and $B_r < p < E$, or if $\max\{D, C_c\} < q < B_c$, then $v = 0$ and the experimental approach will be adopted.*

Proposition 3 is visualized in Fig. 6. Statement i) in the proposition describes the shaded "Exp" block at the top-left corner in the figure. In this situation, each of the players is sufficiently confident that the result of experimentation will prove her belief correct. If the different priors are disclosed, then the players will agree on experimentation, expecting positive payoffs; if the priors are not disclosed, then the do-nothing option will be adopted and the players will get the default zero payoff. Therefore, both of the players would like to see their priors disclosed and then agree on experimentation, taking into consideration the mutually exclusive payoffs. This situation replicates our main result in Proposition 2 that polarization of beliefs can result in agreement to experiment through the players' confidence in being proven correct and winning the mutually exclusive payoff.

Statement ii) in Proposition 3 describes the *J*-shaped, shaded "Exp" block in Figure Fig. 6. In this situation, at least one of the two players is not sufficiently confident that the result of experimentation will prove her correct. If the priors are disclosed, no reform will happen and both players will get the default zero payoff; if their priors are not disclosed, however, the players can reach an agreement to experiment, expecting positive payoffs. Therefore, the players will agree tacitly not

to disclose their priors at the first stage. At the second stage, they will reach an agreement in experimentation, and this agreement will be purely driven by the consideration of the mutually inclusive payoff.[18]

Comparing Fig. 6 with Figs. 2, 4, and 5 further reveals the welfare implication of our extension. As we have illustrated in Section 5, consideration of mutually exclusive payoffs can restore efficiency when the beliefs are diametrically opposite, but can create a new case of under-experimentation when the priors are slightly different, i.e., when p is slightly higher than B_r and q is slightly lower than B_c. The extension with endogenous mutually exclusive payoffs will maintain the efficiency restoration and, at the same time, will erase this new under-experimentation. Therefore, granting the players an option to conceal their priors from outsiders can improve organizational welfare.[19]

7. Two historical illustrations

7.1. The strategic choice in the Chinese transition

Our model provides a plausible answer to why China adopted neither a Big Bang nor a do (almost) nothing approach but instead adopted an experimental approach in its transition. In the transition, the first two key assumptions of our model – different priors and the consensus requirement – are well embedded. First, in terms of different priors, it is now well known that, beginning in the late 1970s, there was a fierce debate among the Communist Party leaders about whether and how to introduce reform in China. One group of leaders, represented by Deng Xiaoping, Hu Yaobang, Zhao Ziyang, Wan Li, and others, focused on open markets and placed special emphasis on economic growth rates. The other group, represented by Chen Yun, Li Xiannian, Wang Zhen, Li Peng, Deng Liqun, Hu Qiaomu, Yu Qiuli, and others, insisted on restoring the command economy in line with the First Five-Year Plan, a Soviet-style scientific economic plan.[20] The debate was witnessed and documented by Deng Xiaoping's speech (1984), Deng Liqun's autobiography (2006), Li Rui's recollection (2008), Bao Tong's interview (2009), Zhao Ziyang's memoir (2009a, 2009b), and Zhang Lifan's talk (2014), and acknowledged by scholars such as Shirk (1993, 1994), Dittmer and Wu (1995), Vogel (2005; 2011), Heilmann (2011), and Xu (2011), as well as via reports in the media, such as *The Economist* (1989) and *The New York Times* (Tyler, 1995).[21] The debate revealed diametrically opposite beliefs held by the two factions inside the Party: Deng Xiaoping's reform faction, and Chen Yun's conservative faction.[22]

Second, the consensus requirement for policy change is one of the most important features of Chinese Communist politics. As Shirk (1993, p. 15) writes, "the Chinese government bureaucracy … always made decisions by consensus" and "consensus decision making institutions tend to be conservative because radical departures from the status quo are blocked by vetoes from groups who stand to lose." A united image of the Party is required by the single-party authority, and, as Huang (2000, p. 411) documents, its leaders debate among themselves privately but must deny any differences on policy in public. Shirk (1994, p. 16) notes that most reform policies were debated in large working conferences where consensus could be reached among the central leadership, provincial representatives, and department ministers. Although some top figures might have exerted a strong influence in such conferences, during the 1980s, power was almost equally distributed between Deng Xiaoping and Chen Yun. As documented in Vogel (2005, p. 742)'s short biography of Chen Yun, "On important issues relating to the economy, ideology, Party organization, and basic Party Policy, it was expected that Deng would seek the ap-

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[18] The other areas in Fig. 6 describe the situation where the solution to the second stage does not depend on whether the players' priors have been disclosed in the first stage, so we assign corresponding solutions to those areas, respectively.

[19] As suggested by the referee, endogenizing the mutually exclusive payoffs can bring some other interesting results if we drop the consensus requirement at the second stage. For example, in Fig. 6, if $B_r < p < E$ and $0 < q < C_c$, the do-nothing option will be adopted at the second stage. Now we assume that the second stage follows a majority rule, with the reformer being the majority. Without disclosure of the priors, the reformer will push experimentation through, while the conservative will expect a negative payoff. With disclosure, the reformer will not pursue the experimental reform because she is not sufficiently confident that the result will prove her correct. The conservative, however, will like this outcome better than in the non-disclosure case, because she will expect zero rather than negative payoff. Therefore, the conservative will disclose the priors at the first stage, and the disclosure will push the reformer to give up experimentation at the second stage. In other words, the disclosure option at the first stage can protect the minority at the second stage.

[20] The names were all significant in Chinese politics. For the reformer faction, Deng Xiaoping was the core of the second generation leaders of China and the Party; Hu Yaobang was the General Secretary of the Party from 1982 to 1987 and Zhao Ziyang was General Secretary from 1987 to 1989; Wan Li was the Vice Premier of China from 1980 to 1988, and the Chairman of the National People's Congress from 1988 to 1993. For the conservative faction, Chen Yun was the only figure who had equivalent political influence to Deng Xiaoping at the time, acting as the Vice Chairman of the Party from 1978 to 1982, serving in the Politburo Standing Committee of the Party from 1977 to 1987, and then holding the position of Director of the Central Advisory Commission, the office for retired senior Party leaders, from 1987 to 1992; Li Xiannian was the President of China from 1983 to 1988 and Wang Zhen was President from 1988 to 1993; Deng Liqun and Hu Qiaomu were leaders of the propaganda and publicity system; Yu Qiuli was the Vice Premier of China from 1975 to 1982 and the Director of the General Political Department of the People's Liberation Army from 1982 to 1987.

[21] Li Rui was first the secretary of Mao and later the Deputy Head of the Organization Department of the Party from 1983 to 1984. Bao Tong was the Policy Secretary of Zhao Ziyang when Zhao was the Premier of China from 1980 to 1985. Zhang Lifan worked at the Institute of Modern History of Chinese Academy of Social Sciences in the 1980s, and was appointed by Hu Yaobang's family as the witness of Hu Yaobang's funeral in 1989.

[22] Shirk (1993, 1994) thoroughly documents the political issues around the Chinese transition before the early 1990s. Zhao (2009a, p. 91–94) documents in detail the differences between the leaders' ideas about the Chinese economy. Xu (2011) cites Deng (1984), Li (2008), Bao (2009), and Zhao (2009a) to document the different opinions toward reform within the Party. Heilmann (2011, p. 84) reads: "Deng Xiaoping and Chen Yun … came to differ substantially with regard to the speed and extent of change."

proval or at least the acquiescence of Chen Yun."[23] The metaphor created by Yang (2004) to describe this equilibrium, the *two-peak politics (shuangfeng zhengzhi),* is now well accepted. The consensus requirement in our model is thus plausible for these two well-matched factions.

The presence of different priors and the consensus requirement made the conservatives' belief critical to the adoption of any reform. Many sources suggest that the conservatives did not believe in the reforms, thinking it not worthwhile to enact reform policies given their expected defects (e.g., Dittmer and Wu, 1995; Huang, 2000, p. 380). For example, in arguably the most famous speech of his career, Chen (1995) emphasized in 1980 that "the mainstay of our country is a planned economy."[24] Heilmann (2011, p. 84) also writes: "... in contrast to Deng, Chen took a very sceptical stance toward the introduction of non-socialist special economic zones ...." (Zhao, 2009a, p. 92) recollects: "Li Xiannian was fully on Chen Yun's side, and even more extreme and stubborn." This situation corresponds to a very small q in our model.[25]

We can further regard the mutually inclusive payoff in our model as national or Party interests as viewed by each of the two factions. Proposition 1 then predicts that the conservatives should always have vetoed any form of reform proposed by the reformer faction. For example, the conservatives should have rejected expanding the special economic zones in coastal areas, but chosen to keep the scientific, planned system as the economy's mainstay, using a market economic approach only as a supplement.

History simply contradicts this prediction. Note that Proposition 1 comes from adding the consensus requirement to the classic option value–delay cost trade-off between the Big Bang and the experimental approaches. The contradiction suggests that this classic trade-off missed something necessary to explain the experimental transition of China.

As Woo (1994, p. 279–280), Roland (2000, p. 36–37), Cai and Treisman (2006), and Xu (2011) have observed, China's adoption of the experimental approach was accompanied by the presence of diametrically opposite beliefs toward the reform. Following this observation, our Proposition 2 proposes an explanation emphasizing this stark difference in beliefs and specifies a novel mechanism by which this difference can drive the experimental reform: when the two factions hold diametrically opposite beliefs, they are both sufficiently confident of being proven correct in the experimental approach, and thereby gaining the contingent, mutually exclusive payoffs, which drives the experimental transition.

The plausibility of this explanation depends on the plausibility of the contingent, mutually exclusive payoffs. By having its position proven correct during the Chinese transition, a faction could not only convince the other faction to adopt its view, but could also affect personnel arrangements, popularize itself among provincial representatives and ministers, and thus gain political power in some outside or future policy discussions.[26] For example, Vogel's biography of Deng Xiaoping (2011) notes, "if something was working, that policy or that person garnered support," and "when economic results came in toward the end of each year, for example, they affected the evaluation of the current economic policy and of the officials responsible for the policy." The quotations suggest that the experiment's result affected not only the conclusions about the experiment, but also the careers of relevant officials, and therefore shifted power between the factions.[27] The existence and significance of these contingent, mutually exclusive payoffs are also consistent with the observation that politicians always avoided association with failed experiments. For example, Vogel (2011, p. 393) documents that, "if something was failing, however, people began to move away and to shun the failure." Shirk (1993, p. 141) also sees that, "if an experimental enterprise somehow turned in a disappointing performance, it was dropped from the program and never mentioned again."

If the contingent, mutually exclusive payoffs were not significant, both factions should hope for a fair experiment through which unbiased information would be revealed. In reality, however, the reformers and the conservatives used their political resources to tilt the experiment toward the outcome they desired, and these tactics suggest the significance of contingent, mutually exclusive payoffs. For example, on the one hand, Shirk (1993, p. 140–141) observes that many of the experiments were "not true experiments but rather 'Potemkin village' models" that were "bolstered with ...cheap material inputs, electricity, bank loans, and so on" so that "there was no way an experiment could fail." On the other hand, success of these experiments was never easy since the conservative bureaucrats always used their political resources to sabotage the experiments by imposing "cutthroat" restrictions on these experiments (e.g., Tu, 2008, p. 101–119; Wang, 2008; Li, 2009,

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[23] In the 1956–1966 seven-person Politburo Standing Committee of the Communist Party of China, the most powerful decision making body in China, Chen Yun ranked fifth in influence, and Deng Xiaoping ranked sixth in influence. After the Cultural Revolution (1966–1976), Deng Xiaoping and Chen Yun were the only two members among the seven members of the 1956–1966 Standing Committee remaining alive. For the years after 1978, Huang (2000, p. 363) writes, "More importantly, these arrangements virtually structured new leadership relations in the years to come: the power in decision making was shared by Deng and Chen, with Li Xiannian, and later Peng Zhen, as the balancing weights." Vogel (2005, p. 756) writes, "At the Third Plenum that followed immediately ratified the new direction laid out at the work conference, Deng Xiaoping, aged 74, sat on the podium with Chen Yun, aged 73."

[24] The statement was spoken during the Central Committee Working Conference on December 16, 1980. It reads *women guojia shi yi jihua jingji wei zhuti de* in Chinese.

[25] In the Chinese transition, the conservatives' belief in the market reform was rather dim, and, as documented in Huang (2000, p. 380), they were always insisting on the central-planned economy as the mainstay. Dittmer and Wu (1995) document that the conservatives' top concerns were economic overheating, inflation, trade deficit, and macro-instability.

[26] There is a phrase *zhengzhi ziben* for this kind of political power in Chinese. A straight English translation would be *political capital.*

[27] In another example, Shirk (1994, p. 19) argues that "contending leaders used reform policy to extend new powers and resources to various groups within the selectorate, and leaders adopted particularistic rather than universal forms of policies, which enabled them to claim credit for giving special treatment to particular organizations and localities." Such credit is also contingent on the success of a given reform policy. If the reform policy is proven incorrect, the leaders and the particular organizations, as well as localities, will lose political support and potential promotion.

p. 79–85).[28] In 1981, Chen Yun even proposed removing Ren Zhongyi, who strongly supported the market reform, from the position of the Party secretary of Guangdong Province, where three among the four earliest special economic zones were located. In Chen Yun's words, the experiments should be supervised by people who were "as firm as an unmovable nail," which would create further difficulties against the success of the experimentation (Zhao, 2009a, p. 104). Facing these obstacles, the reformers had to fight hard to tilt the experiments back toward the outcome they desired.

Some *ex-post* observations also show the plausibility of the mutually exclusive payoffs. For example, as the experimental reform during the Chinese transition is regarded as a huge success, Deng Xiaoping was venerated as "the chief architect of the socialist opening-up and modernized construction of China" when he died in 1997, while Chen Yun received much less acclaim when he died in 1995, even though he was much more senior than Deng Xiaoping during the early days of the Party.[29] Such a difference in acclaim would not have existed or likely would have "flipped" if the experimental reform had failed, especially given the even matching between the two leaders in the late 1970s and early 1980s.[30]

Some other considerations or alternative explanations could emerge in our illustration. For example, there could be conflicting interests that are not based on different beliefs, e.g., the reform could displace the ministries controlled by the conservative, regardless of the success or failure of the reform. This consideration, however, does not explain why the conservative did not veto the reform to avoid this loss of power.[31] An important alternative explanation, following the logic in Roland (2000, p. 36–37) and Hirsch (2016), is that conservatives' approval of the experimental reforms could be driven by the desire to convince the reformers to adopt the correct belief. The alternative explanation fails to explain the different attitudes toward the result of experimentation, the effort to tilt the result, or the significant changes in political power after the reform. Another explanation could be logrolling, namely, that one faction might compromise on a policy in exchange for cooperation in other issues. This explanation, however, would conflict with the political-economic cycle in the 1980s. As documented in Dittmer and Wu (1995) and Zhao Ziyang's memoir (2009a), following problems with the market reform, such as overheating and economic crimes, the conservative had more political power to push back not only the economic but also the ideological reforms, which fits our logic. The explanation about logrolling, however, would predict that regressive ideological policies should generally coincide with progressive economic policies and not depend on the result of these progressive economic policies.

To summarize, our mechanism about the mutually exclusive payoffs does provide an empirically relevant explanation for the experimental transition of China among the conventional wisdom of one reformer weighing the option value and the delay cost of the experimental approach and other alternative considerations.

7.2. Which way to Germany, and why Operation Market–Garden

The aftermath of the Allied victories in Normandy and Paris in August–September 1944 saw a famous argument within the leadership of the Allied Forces as to which strategy should be adopted on the Western Front to defeat Hitler. Dwight Eisenhower, the Supreme Commander of the Allied Forces in Europe (and later President of the United States), proposed crossing the Rhine and reaching the Ruhr on a broad front with the British forces (Field Marshall Bernard Montgomery) coming via the north and the American forces (General of the Army Omar Bradley and General George Patton) via the south of the Ardennes. However, Montgomery, with Churchill's backing, preferred a single, concentrated thrust only through the north. Instead of directly concentrating forces toward the north to implement the single thrust in a Big Bang approach at the strategic level, another option, which came to be called Operation Market–Garden, could be adopted at the operational level by seizing a bridgehead over the Rhine near Arnhem, which is in the north, with an ambitious thrust, but at the cost of delaying the opening of the port of Antwerp. As noted by the renowned historian and grandson of Dwight Eisenhower, David Eisenhower (1986, p. xxiii, 442, 445), this operation "would disrupt Eisenhower's plans ... not decisively" but it "was

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[28] For example, Tu (2008, p. 101–108) and Wang (2008) document that, after a four-cent bonus effectively encouraged workers in special economic zones to increase productivity, the use of economic incentive was deliberately banned by the central government, resulting in a regression and delay in production. Tu (2008, p. 108–119), Wang (2008) and Li (2009, p. 79–85) also discuss the manmade obstacles against special economic zones' investment in transportation and communication technologies. Li Lanqing was the Vice Premier of China from 1998 to 2003 and serving in the Politburo Standing Committee of the Party from 1997 to 2002.

[29] Vogel (2005, p. 743) notes: "Although Deng was one year older than Chen Yun, Chen Yun had seniority within the Party. From 1931 when he became a member of the Central Committee until 1956, Chen Yun held higher positions than Deng and even after 1956 outranked Deng in the official Party ranking. In 1935, at the famous Zunyi Conference so critical to Mao's rise to pre-eminence, Chen Yun participated not only as a member of the Central Committee but as a member of its standing committee. Deng attended the same meeting as a note taker."

[30] We can also talk a little bit more about the mutually exclusive payoffs from the Big Bang approach. On the one hand, we argue that the result of a Big Bang reform could not give significant contingent, mutually exclusive payoffs to the two factions. The reason is: under the consensus requirement, the conservative would find it hard to claim their victory over the reformers if the Big Bang reform failed, since the reformers could ask "why did you *not* reject the Big Bang approach?" The reformers would also find it difficult to claim their victory if the Big Bang reform succeeded, since the conservative could state "we did approve the Big Bang approach!" The question and the statement would make the victors' claims much weaker. On the other hand, even if the Big Bang approach could bring significant mutually exclusive payoffs, we can argue that the conservative would not dare to try the Big Bang approach, since a failed Big Bang reform could provoke an economic disaster (and it would be very likely to cost the Party's governance position in China). This discussion suggests that both Propositions 2 and 4 (in Appendix A.5) are applicable.

[31] Similarly, it could be the case that the two factions had different opinions about the market reform because the conservative were more risk- or loss-averse, but this consideration cannot explain why the conservative did not use their veto power to avoid the risk or potential loss.

to be the preliminary in Montgomery's proposed forty-division thrust," and, therefore, could serve as an experiment to "test the validity" of Montgomery's idea.

The first key assumption of our model, the diametrically opposite beliefs of the decision makers, was documented by many witnesses (e.g., Eisenhower, 1948, p. 306–307; Montgomery, 1958, p. 238–257, Ill. 42; Churchill, 1959, p. 877–878) and historians (e.g., Ambrose, 1990, p. 153–159; Murray, 1996; Baxter, 1999, p. 89–100; D'Este, 2002, p. 594–609).[32] Montgomery genuinely believed that the German defense was incapable of any serious resistance in the face of a concentrated attack from the north of the Ardennes, and that his single-thrust strategy would easily open the road to Berlin and finish the war by Christmas 1944. Eisenhower, however, did not buy the idea at all, as he well understood that the Germans still had the ability to make a last-ditch effort and that a broad front by the Allies was necessary to seize the Ruhr. The divergence of their beliefs was so deep that Eisenhower and Montgomery even had a tense face-off on September 10, 1944.[33]

The second key assumption of our model, the consensus requirement, was also present: As Eisenhower was the Supreme Commander, any deviation from his broad-front strategy needed his approval. It is also obvious, as noted by David Eisenhower (1986, p. 445), that the single-thrust strategy would not be adopted in any approach unless "Montgomery insisted."

Historical accounts have revealed that Eisenhower dismissed the single thrust at the strategic level, since he could not risk the victory of the Western Allies in the war against Hitler and in the competition with Stalin. He agreed with Montgomery, however, to execute Operation Market–Garden. This operation turned out to be a disaster.[34] The failure of Market–Garden and the delay of the opening of Antwerp gave the Third Reich a breathing space, and effectively quashed Montgomery's plan at the strategic level and any hope of the Allies to finish the war in 1944. Eisenhower's broad front eventually took place.

As many strategists and historians have noted, Montgomery's proposal of Market–Garden was more foolish than risky. For example, General of the Army Omar Bradley (1951, p. 416) said: "Monty's plan for Arnhem was one of the most imaginative of the war. Just as soon as I learned of Monty's plan, I telephoned Ike and objected strenuously to it."[35] Brighton (2008, p. 334) quotes Major Brian Urquhart, the British intelligence officer who was suspended for warning of the infeasibility of the plan, considering the operation to be "an unrealistic, foolish plan." A famous question in political and military history then arises: Why did Eisenhower "not only approve" but also "insist upon" Montgomery's risky, if not foolish, Market–Garden plan (Dwight Eisenhower, 1970, p. 2135)?

Several potential explanations have been offered. First, Eisenhower might have approved Market–Garden only on military grounds as he might have considered Market–Garden to be a "silver bullet" to seize a strategic bridgehead over the Rhine. However, as the flaws in the plan should have been obvious to Eisenhower, and the blow of Market–Garden was so heavy, this explanation cannot convince historians like Baxter (1999, p. 95), D'Este (2002, p. 603), and Ambrose (2012, p. 513).[36] Brighton (2008, p. 334) also quotes Urquhart as saying that the operation "had been dictated by motives which should have played no part in a military operation." This explanation was even refuted by Eisenhower himself, as he wrote to General Hastings Ismay in 1960, as quoted by D'Este (2002, p. 618), that "my staff opposed it but because he was the commander in the field, I approved."

Second, some people believe that Eisenhower approved Market–Garden to appease Montgomery (e.g., Ambrose, 1990, p. 165).[37] As noted by Brighton (2008, p. 335), however, "after the war when this was put to Eisenhower he strongly denied it", and, had Eisenhower "intended Market–Garden to keep Monty quiet, it did not." It is also difficult to believe that Eisenhower invited a huge blow to the American Forces (especially the 82nd and the 101st Airborne Divisions) only to make Montgomery happy. Third, as noted by David Eisenhower (1986, p. 445), his grandfather "could negotiate with Montgomery on the basis of Market–Garden …in hopes of defusing" their argument, but this "would involve making concessions beyond those" Eisenhower "had already made, and set the bad example of rewarding intransigence by negotiating under duress, which could not pass unnoticed by the Americans."

As thoroughly supported by David Eisenhower's Pulitzer-finalist book (1986), another explanation emerges as we examine the political background of the Eisenhower–Montgomery controversy. The argument took place within a larger picture of the competition between the Anglo–American cousins over the leading role within the Allied Forces, the distribution of the historical glory of defeating Hitler, and their influence in Europe after the war. Eisenhower and Montgomery were the

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[32] Also see Murray (1996) and Baxter (1999, p. 89–100) for detailed accounts of the bibliography on this argument.

[33] For details about the meeting, see Ambrose (1990, p. 163) and D'Este (2002, p. 605–606).

[34] Coble (2009, p. 1) states that the "casualty count …among three participating Allied airborne divisions …was more than among all Allies on 6 June 1944, the first day of Operation Overlord" – the day of the Normandy landings. The most famous book about Operation Market–Garden could be Ryan (1974)'s *A Bridge Too Far*. Also see Montgomery (1947, 1958), Eisenhower (1948, 1970), Bradley (1951), Wilmot (1952), Churchill (1959), Eisenhower II (1986), Ambrose (1990, 2012), Murray (1996), Baxter (1999), D'Este (2002), and Brighton (2008), and the references they cite.

[35] Montgomery was nicknamed "Monty," while Eisenhower was nicknamed "Ike."

[36] As quoted by Baxter (1999, p. 95) and D'Este (2002, p. 603), Ambrose (2012, p. 513) states that "Eisenhower could not make his decisions solely on military grounds."

[37] Ambrose (1990, p. 165) reads: "But of all the factors that influenced Eisenhower's decisions – to reinforce success, to leap the Rhine, to bring the highly trained but underutilized paratroopers into action – the one that stands out is his desire to appease Montgomery." Brighton (2008, p. 335) writes that "the Americans at SHAEF believed" that Eisenhower "did so as a sop to Montgomery – that, having turned down his plan for a single thrust, he accepted Market–Garden to appease him, and would have turned it down if the plan had been considered on military grounds alone." The SHAEF is the abbreviation of the Supreme Headquarters Allied Expeditionary Force.

representatives of the American and British interests in the political competition.[38] David Eisenhower (1986, p. 444) sharply points out that "Berlin was not what the British had in mind; what they wanted was a dominant voice within the Allied command." If the British did dominate within the Allied command, and if Montgomery's single thrust did succeed with guaranteed strategic priority of the Allied Forces, the British would reap much more glory and postwar political power in Europe than if, as it turned out, the American and the British voices were balanced within the Allied command and Eisenhower's broad-front strategy worked out almost as planned. As noted by Ambrose (2012, p. 513) and quoted by Baxter (1999, p. 95) and D'Este (2002, p. 603), however, "under no circumstances would Eisenhower agree to give all the glory to the British."[39] Under this background of the political competition, Montgomery and Eisenhower should both have clearly understood that a successful Market–Garden would divert the competition toward the British, while a failed one would make it more balanced toward the Americans. This is the third key assumption of our model, the contingent, mutually exclusive payoffs.

Many people agree that mutually exclusive payoffs were one of the main reasons for Montgomery's enthusiasm toward the operation. For example, quoted by Brighton (2008, p. 335), Edgar Williams, Montgomery's Chief Intelligence Officer, talked about Montgomery's motive: "He thought that success would tilt the centre of gravity and give the British priority of supplies before the US armies. Probably Monty thought then it was just a question of who put in the final punch against a defeated enemy before a final victory. If this airborne drop succeeded in front of his Second Army drive, his punch not Patton's would be the triumphal road to final victory."[40] It is also natural to propose that one important reason for Eisenhower's approval of Operation Market–Garden was to prove Montgomery and his strategy wrong and therefore gain an advantage for the Americans in the political competition. We are not alone in this proposal; David Eisenhower (1986, p. xxiii) clearly makes his point on his grandfather's motive:

> Eisenhower ... was left with a third course: Calling Montgomery's bluff by authorizing Market–Garden ... but doing so within carefully prescribed limits. Eisenhower's recourse was to allow – indeed, order – Montgomery to proceed with a doomed operation that would test the validity of his idea that the Germans were incapable of further resistance.

According to David Eisenhower (1986, p. xxiii) (summarized by Baxter, 1999, p. 102), his grandfather knew that "Montgomery would be effectively silenced" by "a severe if local setback in Holland" and "must fail and be placed thereafter in [a] subordinate role."[41] In other words, Eisenhower was pursuing mutually exclusive payoffs with the confidence of being proven correct in the experiment, following exactly the logic of our main result. Given these interpretations, Operation Market–Garden was indeed a "silver bullet" for both Eisenhower and Montgomery, but, rather than to defeat Hitler, this "silver bullet" is more for them to win the political competition between the Anglo–American cousins.

The good fit of our model is further strengthened by the aftermath of Operation Market–Garden, which was consistent with the existence of significant mutually exclusive payoffs. Churchill (1959, p. 881) and Montgomery (1947, p. 149) denied that Market–Garden failed, by claiming "a decided victory" that was "ninety per cent successful."[42] As noted by D'Este (2002, p. 618), Montgomery scapegoated Generał Brygady Stanisław Sosabowski, who had seriously opposed the plan beforehand but still commanded the Polish 1st Independent Parachute Brigade with a gallant battle in the operation. Despite taking responsibility as the Supreme Commander, Eisenhower (1970, p. 2135)'s pleasure in being proven correct was clear and consistent: "What this action proved was that the idea of one 'full-blooded thrust' to Berlin was silly."[43] After Market–Garden, Eisenhower gained a much stronger position in his argument with Montgomery and even Churchill. Grigg (1993, p. 110) notes that "there was surely a strong case for removing" Montgomery "after Arnhem." Ambrose (1990, p. 167) also notes that, at that time, "Montgomery knew full well that if Eisenhower told the CCS it was 'him or me,' Eisenhower would win."[44] For Eisenhower, the Anglo–American balance within the leadership of the Allied Forces became more stable, and

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[38] See documentation of many historians, e.g., David Eisenhower (1986, p. 445), D'Este (2002, p. 603), Ambrose (2012, p. 504–535), and the references in Baxter (1999, p. 95).

[39] D'Este (2002, p. 603) also states: "Although Eisenhower may well have convinced himself his broad front decision was primarily military, the political aspects simply could not have been ignored. 1944 was a presidential election year in a war being fought by allies. From the time he took command of Torch in North Africa his role, indeed the very basis of his success, had been unity in a war, which would be won by allies, not by British or Americans, acting singularly."

[40] General George Patton was mentioned here as the American force that would advance south of the Ardennes under the broad-front strategy that was led by Bradley and Patton. D'Este (2002, p. 610) also writes that "Montgomery was convinced that Eisenhower would be obliged to give priority to this single-thrust concept" once the operation succeeded. Brighton (2008, p. 335) reads: "If Arnhem succeeded, the Allies would in all probability 'go with a winner' and throw everything into the Montgomery thrust into the Ruhr at the expense of all other operations. They would then be operating to Montgomery's single-thrust strategy and, as the army commander on the spot, he could expect that any 'request' for overall command would be granted. We must suspect that he took the risk at Arnhem because it was the only operation that would, in one stroke, allow him to get his way – in command and in strategy – and enable him to direct the war to the early end that he genuinely believed was possible."

[41] Coble (2009, p. 32) also comments that "Eisenhower sacrificed an Allied division to allow Montgomery to prove" that the single-thrust strategy was wrong.

[42] Montgomery (1958, p. 265–266) summarized four main reasons for the failure of the operation: 1) low priority of the operation in Eisenhower's agenda; 2) his own mistake in deciding where to drop airborne forces; 3) bad weather; and 4) incorrect estimates of the strength of the German Panzer Corps. He took responsibility for only one of the four reasons. Montgomery (1958, p. 267) further stated that the operation "would have succeeded *in spite of* my mistake", and that "I remain Market–Garden's unrepentant advocate."

[43] Eisenhower (1948, p. 307) also hinted at attributing the decision of Market–Garden to Montgomery, as his memoir reads abruptly: "Montgomery was very anxious to attempt the seizure of the bridgehead."

[44] The CCS is the abbreviation of the Combined Chiefs of Staff for the western Allies. Ambrose (2012, p. 533) also states that after Market–Garden, "almost all Eisenhower's associates, British and American, agreed that the Supreme Commander was more tolerant of strong dissent from Montgomery

the Allied (and the American) interests were better secured. These observations also support our model over a competing explanation, along the line of Hirsch (2016), that Eisenhower and Montgomery agreed upon Operation Market–Garden only to convince the other: If so, there would not have been such a sharp difference between the attitudes of Eisenhower and Montgomery toward the experiment's result and such a serious impact on the balance between the Anglo–American cousins in ensuring the political competition. We conclude that the setting, prediction, and logic of our model well fit the Eisenhower–Montgomery dispute and the decision concerning Operation Market–Garden.

8. Concluding remarks

In this paper, we propose and formalize the mechanism of Machiavellian experimentation, positing that polarization of beliefs could make decision makers agree to policy experimentation if they are pursuing significant mutually exclusive payoffs from being proven correct by the result of the experimentation. This mechanism contrasts with conventional thinking that experimentation requires moderate but not extreme beliefs.

Several extensions can be made. For example, one can model the micro-foundations of contingent, mutually exclusive payoffs. After the initial strategy adoption problem, there could be a separate bargaining game between the two players, and the mutually exclusive payoffs in the strategy adoption problem could be a potential increase or decrease in the parties' relative bargaining power in the bargaining game. In extreme cases, the result of the experiment could wipe the player proven incorrect out of the bargaining game. More micro-foundational analysis could include reputation concerns (e.g., Levy, 2007a, 2007b), intragroup conflicts (e.g., the survey by Jehn and Bendersky, 2003), and linkage between issues, an important topic in international cooperation and conflict resolution (e.g., Haas, 1980; McGinnis, 1986; Davis, 2004).

Another interesting extension would be some comparative statics around the informativeness of the experiment. On the one hand, in terms of the mutually inclusive payoff, if the experiment does not immediately reveal whether the new policy will work, then experimentation will become less favorable for both players, *ceteris paribus.* On the other hand, a less informative experiment should make the mutually exclusive payoffs smaller, since the experiment's result is less convincing. One can pursue this extension further by endogenizing the scale of experimentation.

The key logic of our result can be applied to many other situations. We conclude by mentioning one of them. We consider a transaction in financial markets to be an adoption of an ownership transfer of a financial asset with the mutual consent of the seller and the buyer. The transaction will prove whether the buyer's (or the seller's) belief on a rising (or decreasing) price in the future is correct or incorrect, and being proven correct (or incorrect) results in profit (or loss). The key logic in our model implies straightforwardly that, in the period when the market beliefs about the future change of the price of a financial asset are more heterogeneous, we should see larger trading volume or higher turnover than in the period with less heterogeneous beliefs. This thinking is at the heart of the studies on the implications of heterogeneous beliefs for financial markets (e.g., Varian, 1989; Harris and Raviv, 1993; Kandel and Pearson, 1995; surveys by Hong and Stein, 2007; Xiong, 2013).

Appendix A. Appendices

A1. An example of equivalent non-cooperative games

This section presents an example of the non-cooperative games that can replicate and refine the results from the cooperative game in the main text. We include both the mutually inclusive payoff and the unextended mutually exclusive payoffs here.

We assume all of the priors and payoffs are common knowledge. There are two stages of the game: at the first stage, the reformer provides a proposal, which includes one of the three options – Big Bang approach, experimental approach, or doing nothing; at the second stage, the conservative decides to accept the proposal or reject it. Fig. A.7 shows the extensive form of this game.

The outcomes of the subgame perfect Nash equilibrium with pure strategies are almost the same as the core of the cooperative game in the main text. The only difference is that there is a situation where the Big Bang and the experimental approaches are both in the core of the cooperative game, while only the Big Bang approach will be adopted in this non-cooperative game, since the reformer is the first-mover.

A2. Proof of Proposition 1

As Fig. 1 shows, since $A_r > B_r > C_r$, we can divide the reformer's preference between the three options into four ranges: if $A_r < p \leq 1$, then the Big Bang approach is the best while doing nothing the worst; if $B_r < p < A_r$, then the experimental approach is the best while doing nothing still the worst; if $C_r < p < B_r$, then the experimental approach is the best while the Big Bang approach the worst; if $0 \leq p < C_r$, then doing nothing is the best while the Big Bang approach still the worst. We can also apply the similar treatments to the conservative. Proposition 1 is then proved by some algebra.

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than he should have been." "In its way it was a repeat performance of Goodwood, when the feeling at SHAEF and among the American field commanders was that Montgomery should have been relieved." SHAEF is the abbreviation of the Supreme Headquarters Allied Expeditionary Force.
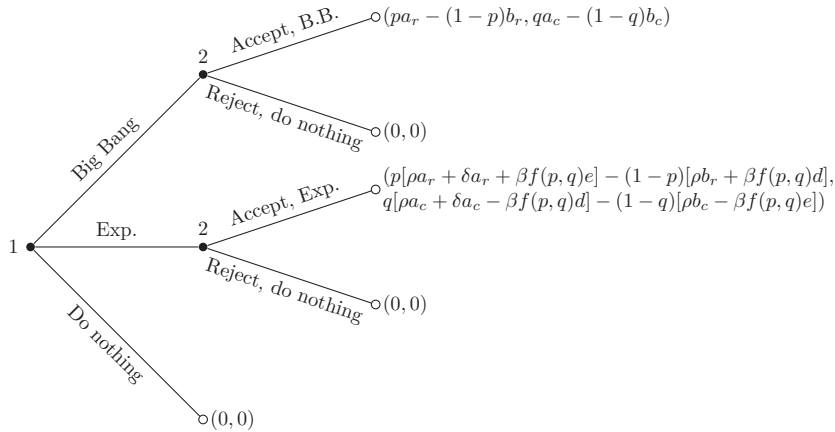
1: Reformer; 2: Conservative. $f(p, q) = 1$ if $p \in (B_r, 1]$ and $q \in [0, B_c)$; otherwise $f(p, q) = 0$.

Fig. A.7. The extensive form of the non-cooperative game.

A3. Proof of Proposition 2

Consider $f(p, q) = 1$, which yields $p \in (\frac{b_r}{a_r + b_r}, 1]$ and $q \in [0, \frac{b_c}{a_c + b_c})$. Also assume $\beta > \frac{\rho(a_c + b_c) + \delta a_c}{e + d}$. The experimental approach will be adopted if, and only if,

$$
\begin{aligned}
&p(\rho a_r + \delta a_r + \beta e) - (1 - p)(\rho b_r + \beta d) > 0 \text{ and} \\
&q(\rho a_c + \delta a_c - \beta d) - (1 - q)(\rho b_c - \beta e) > 0.
\end{aligned}
\tag{A.1}
$$

Otherwise nothing will be done. Proposition 2 is then proved by some algebra.

A4. Comparative statics

To demonstrate the mechanism of our main result we now analyze the comparative statics of the model when contingent, mutually exclusive payoffs are effective ($B_r < p \leq 1$ and $0 \leq q < B_c$). By comparative statics, we mean how the magnitude of the mutually exclusive payoffs, d and e, affects the size of the area occupied by "Experiment" within the shaded area in Fig. 4, and how the weight of the mutually exclusive payoffs, β, changes the solution pattern of the shaded area.[45]

A4.1. The impact of the magnitude of the mutually exclusive payoffs

Assume $\beta > \max\{\frac{\rho(a_c + b_c) + \delta a_c}{e + d}, \frac{\rho b_c}{e}\}$. By Eq. (2), we can derive that D, the break-even prior between the experimental approach and doing nothing for the conservative is weakly increasing in the contingent reward e, while the corresponding break-even prior E for the reformer is weakly decreasing in e.[46] Note that in Fig. 4, the size of the area of interest is increasing in D and decreasing in E, and thus it is weakly increasing in e. The intuition is simple: with a larger contingent reward e, the players will have more incentive to agree to an experimental approach.

The analysis around the contingent punishment d follows the same logic: With a larger contingent punishment d, the players will have less incentive to agree to an experimental approach, so the size of the area of interest is weakly decreasing in d.

To see how the relative scale of d and e affects the size of the area of interest, we consider the extreme case in which β approaches infinity, i.e., the players care almost entirely about the effective mutually exclusive payoffs but hardly about the mutually inclusive payoff. In this extreme case, Eq. (2) tells that D approaches $\frac{e}{e + d}$ and E approaches $\frac{d}{e + d}$. For any given prior pair (p, q), if $\frac{e}{d}$ decreases, then the relative gain in an experimental approach shrinks, and the experimental approach becomes less preferable for both of the players. If $\frac{e}{d}$ approaches zero, there will be no experimental approach adopted at all. To conclude, the size of the area of interest is increasing in $\frac{e}{d}$ when β approaches infinity.

A4.2. The impact of the weight of the mutually exclusive payoffs

We now focus on the solutions to the model if the players do not care enough about the mutually exclusive payoffs ($\beta < \max\{\frac{\rho(a_c + b_c) + \delta a_c}{e + d}, \frac{\rho b_c}{e}\}$). Appendix A.3 details the solutions to the model with different β.

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[45] The comparative statics around the experimental scale, ρ, is less straightforward, so we do not detail it here. The main point is, that the monotonicity of D with respect to ρ is ambiguous, although E is monotonically increasing in ρ, which means the monotonicity of the size of the area of interest in ρ is ambiguous.
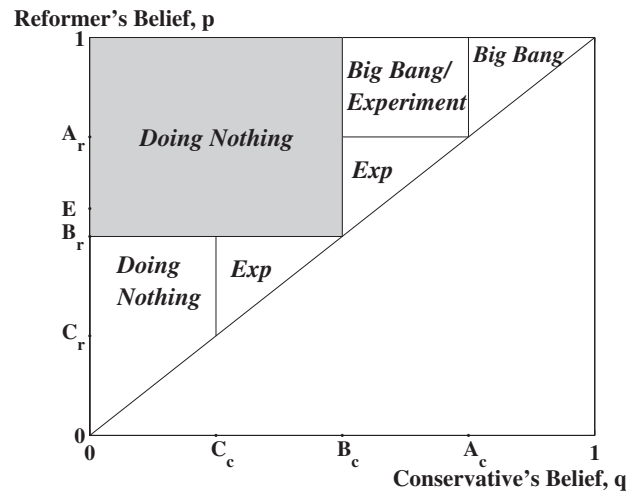
[46] If $D > B_r$ and $E < B_r$, then the entire shadowed area in Fig. 4 is occupied by the experimental approach.
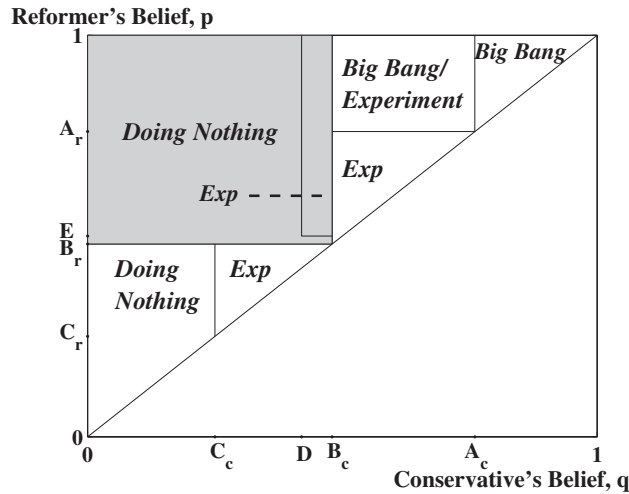
$a_r = a_c = 1.1, \; b_r = b_c = 1, \; e = 2.4, \; d = 8, \; \rho = 0.29, \; \delta = 0.50, \; \beta = 0.1$
$A_r = A_c = 0.76, \; B_r = B_c = 0.48, \; C_r = C_c = 0.25, \; D = 0.42, \; E = 0.50$

Fig. A.8. The typical case with small β.

$a_r = a_c = b_r = b_c = 2, \; e = 1, \; d = 5, \; \rho = 0.25, \; \delta = 0.50, \; \beta = 0.4$
$A_r = A_c = 0.75, \; B_r = B_c = 0.5, \; C_r = C_c = 0.25, \; D = -0.25, \; E = 0.57$

Fig. A.9. One typical case with moderate β.

If the players care little about the mutually exclusive payoffs ($\beta < \min\{\frac{\rho(a_c+b_c)+\delta a_c}{e+d}, \frac{\rho b_c}{e}\}$), then the model solution, as illustrated in Fig. A.8, should be similar to the case with only mutually inclusive payoff, as illustrated in Fig. 2. The two figures are similar in that "Experiment" always occupies the upper right part of the shaded area, and in that the experimental approach is adopted only when the conservative hold moderate priors.

If the players care moderately about the mutually exclusive payoffs, we have two cases: $\frac{\rho(a_c+b_c)+\delta a_c}{e+d} < \beta < \frac{\rho b_c}{e}$ and $\frac{\rho b_c}{e} < \beta < \frac{\rho(a_c+b_c)+\delta a_c}{e+d}$. In the first case, we have $-\rho b_c + \beta e > \rho a_c + \delta a_c - \beta d$ but $-\rho b_c + \beta e < 0$. The two inequalities indicate, that in the presence of the mutually exclusive payoffs, the conservative prefers a failed experiment to a successful one, but a failed experiment is still worse than doing nothing. The conservative then always vetoes the experimental approach, and the policy will not be adopted, no matter how large the reformer's prior is. Fig. A.9 illustrates the case, in which "Doing Nothing" occupies the entire shaded area.

In the second case, we have $-\rho b_c + \beta e < \rho a_c + \delta a_c - \beta d$ and $-\rho b_c + \beta e > 0$. The inequalities imply that the conservative prefers a successful experiment to a failed one, and even a failed experiment is better than doing nothing. She will then always prefer the experimental approach to doing nothing, even when her prior q approaches zero. Now whether to adopt
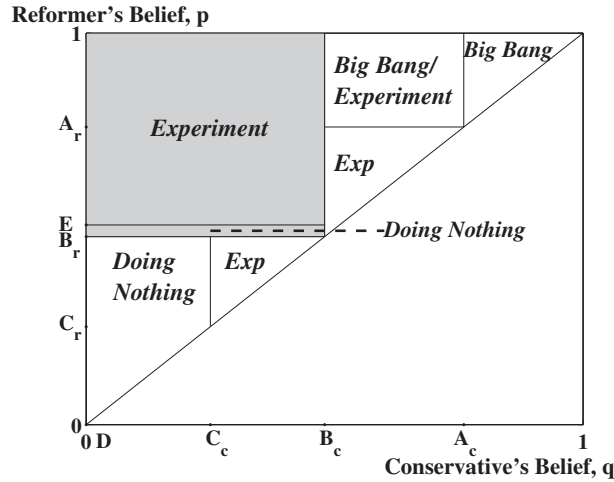
$$a_r = a_c = 1.1, \ b_r = b_c = 1, \ e = 1, \ d = 2.6, \ \rho = 0.33, \ \delta = 0.50, \ \beta = 0.34$$
$$A_r = A_c = 0.78, \ B_r = B_c = 0.48, \ C_r = C_c = 0.27, \ D = -0.53, \ E = 0.51$$

Fig. A.10. Another typical case with moderate β.

the experimental approach depends on the reformer decision. One typical situation with $E > B_r$ is illustrated by Fig. A.10, where "Experiment" covers only the upper part of the shaded area, since the reformer is afraid of losing too much politically during the experimental approach when $B_r < p < E$.

A5. Contingent, mutually exclusive payoffs from the Big Bang approach

We have been implicitly assuming that the Big Bang adoption does not bring mutually exclusive payoffs. The justification is that, under the consensus requirement, agreeing to the Big Bang approach could make it very difficult for the two players to claim a contingent reward against each other, and only the experimental approach could serve easily as an agreed test between the two players. For example, when two parties are forming a coalition government, the mutually exclusive payoffs are the shift of popularity between them. When there is a reform following the Big Bang approach, however, is difficult to show voters the existence of different beliefs within the coalition, so it is difficult to generate mutually exclusive payoffs.

That said, one can still argue that it is possible that the Big Bang approach could bring mutually exclusive payoffs, as the experimental approach does, but on a much larger scale, since the information revealed by the large-scale, Big Bang implementation should be more convincing than small-scale, experimental implementation. This section follows this logic and extends the contingent, mutually exclusive payoffs to the Big Bang approach. We will show that the experimental approach will still be associated with diametrically opposite beliefs as long as the Big Bang approach is not favorable to the conservative.

We assume the following payoff structure to replace the mutually exclusive payoffs, which are assumed in Section 4:

Extended contingent, mutually exclusive payoffs. If the result of an adoption on the scale s shows the policy is good, then the reformer gets $f(p, q)h(s)$, while the conservative gets $-f(p,q)g(s)$; if the result of reform shows the policy is bad, then the reformer gets $-f(p,q)g(s)$, while the conservative gets $f(p, q)h(s)$. When the adoption follows the Big Bang approach, $s = 1$; when the adoption follows the experimental approach, $s = \rho \in (0, 1)$; when there is no adoption and nothing is done, $s = 0$. The indicator function $f(p, q)$ shows whether the payoff structure is *effective*, where $f(p, q) = 1$ if $B_r < p \leq 1$ and $0 \leq q < B_c$; otherwise, $f(p, q) = 0$. The contingent reward and the punishment functions are $h(s) = es^\theta$ and $g(s) = ds^\theta$, where $e > 0$, $d > 0$, and $\theta > 0$.[47]

We call this payoff structure *extended contingent, mutually exclusive payoffs*, because it extends the contingent, mutually exclusive payoffs to the Big Bang approach. Because $\theta > 0$, the scale of the extended contingent, mutually exclusive payoffs is increasing in the scale of the adoption. Sometimes we abbreviate extended contingent, mutually exclusive payoffs as extended mutually exclusive payoffs. When the difference between the contingent, mutually exclusive payoffs and the extended mutually exclusive payoffs is not important, we call both of them mutually exclusive payoffs. Table A.4 shows the expected payoff from the two approaches and doing nothing when the extended mutually exclusive payoffs are effective.

---

[47] This functional form is assumed to investigate the return to scale of the mutually exclusive payoffs.

Table A.4

Expected mutually inclusive and weighted extended mutually exclusive payoffs from the three options when the extended contingent, mutually exclusive payoffs are effective.

Player	Big Bang approach	Experimental approach	Doing nothing
Reformer	$p[a_r + \beta h(1)] - (1-p)[b_r + \beta g(1)]$	$p[\rho a_r + \delta a_r + \beta h(\rho)] - (1-p)[\rho b_r + \beta g(\rho)]$	0
Conservative	$q[a_c - \beta g(1)] - (1-q)[b_c - \beta h(1)]$	$q[\rho a_c + \delta a_c - \beta g(\rho)] - (1-q)[\rho b_c - \beta h(\rho)]$	0

In the case of $f(p, q) = 1$, i.e. $p \in (B_r, 1]$ and $q \in [0, B_c)$.

Similar to Section 4, we also define the break-even priors of the trade-off between the experimental approach and doing nothing, for both the conservative and the reformer, by

$$D' = \frac{\rho b_c - \beta h(\rho)}{\rho a_c + \delta a_c + \rho b_c - \beta(h(\rho) + g(\rho))}, \quad E' = \frac{\rho b_r + \beta g(\rho)}{\rho a_r + \delta a_r + \rho b_r + \beta(h(\rho) + g(\rho))}. \tag{A.2}$$

With the two newly-introduced indifference priors, we proceed with Proposition 4.[48]

Proposition 4. *Assume the two players have different preferences between the Big Bang approach and doing nothing when considering only the mutually inclusive payoff. Then the extended contingent, mutually exclusive payoffs are effective. Further assume that the conservative prefers doing nothing over the Big Bang approach for any prior with effective extended contingent, mutually exclusive payoffs. If the players strongly care about the extended contingent, mutually exclusive payoffs, then the following three statements are true:*

  i) *If the conservative sufficiently disbelieves in the policy while the reformer sufficiently believes in the policy, then the experimental approach will be adopted.*
  ii) *Otherwise, the policy will not be adopted.*
  iii) *The extended contingent, mutually exclusive payoffs have decreasing returns to scale.*

   Mathematically and more precisely, assume $B_r < p \leq 1$ and $0 \leq q < B_c$. Then $f(p, q) = 1$. Further assume $q(a_c - \beta g(1)) - (1-q)(b_c - \beta h(1)) < 0$ holds for any $q \in [0, B_c)$ (which is equivalent to assuming $\beta < \frac{b_c}{h(1)}$ and $\frac{a_c}{b_c} < \frac{d}{e}$). If $\beta > \max\{\frac{\rho(a_c+b_c)+\delta a_c}{h(\rho)+g(\rho)}, \frac{\rho b_c}{h(\rho)}\}$, then the following three statements are true:

  i) *If $0 \leq q < \min\{D', B_c\}$ and $\max\{B_r, E'\} < p \leq 1$, then the experimental approach will be adopted.*
  ii) *If $D' < q < B_c$ or $B_r < p < E'$, then the policy will not be adopted.*
  iii) *$\theta < 1$.*

Appendix A.5.1 proves Proposition 4. The intuition is as follows. When the extended mutually exclusive payoffs are effective and the conservative prefers doing nothing over the Big Bang approach for any prior with effective extended contingent, mutually exclusive payoffs, the conservative will still veto the Big Bang approach as in Proposition 2.[49] When the players strongly care about the extended mutually exclusive payoffs ($\beta > \max\{\frac{\rho(a_c+b_c)+\delta a_c}{h(\rho)+g(\rho)}, \frac{\rho b_c}{h(\rho)}\}$), Results i) and ii) then follow the same logic as in Proposition 2. In this case, as an extreme conservative ($q = 0$) prefers the experimental approach over doing nothing and doing nothing over the Big Bang approach, she should prefers the experimental approach over the Big Bang approach. This preference suggests that the extended mutually exclusive payoffs cannot increase very fast in the adoption scale ($\theta < 1$), which is Result iii). Otherwise, the contingent reward from the Big Bang approach would be much larger than that from the experimental approach and the extreme conservative would then like the Big Bang approach even better than the experimental approach. In other words, the mutually exclusive payoffs should dominate the mutually inclusive payoff in the extreme conservative's evaluation of the experimental approach, but vice versa in her evaluation of the Big Bang approach.

A5.1. Proof of Proposition 4

When the conservative prefers doing nothing over the Big Bang approach,

$$q[a_c - \beta g(1)] - (1-q)[b_c - \beta h(1)] < 0, \text{ i.e. } q[a_c + b_c - \beta(g(1) + h(1))] < b_c - \beta h(1). \tag{A.3}$$

In Eq. (A.3) derives the following Lemma.

Lemma 1. *If In Eq. (A.3) holds for any $q \in [0, \frac{b_c}{a_c+b_c})$, then $b_c - \beta h(1) > 0$, and either 1) $a_c + b_c - \beta(h(1) + g(1)) < 0$, or 2) $a_c + b_c - \beta(h(1) + g(1)) > 0$ and $\frac{b_c - \beta h(1)}{a_c+b_c-\beta(g(1)+h(1))} > \frac{b_c}{a_c+b_c}$.*

The intuition of the two cases follows the same logic as our discussion for Proposition 2. Now let's consider the two Cases.

---

[48] For simplicity, we only consider the cases in which p and q are not equal to any of the indifference priors.

[49] The simple expression of the relative size relies on the specification of $h(s) = es^\theta$ and $g(s) = ds^\theta$. Other specifications, for example, a linear specification of $h(s)$ and $g(s)$, will not derive the same simple expression, but still carry the same intuition.

Case 1. This case requires $a_c + b_c - \beta(h(1) + g(1)) < 0$ and $b_c - \beta h(1) > 0$. The requirement derives $\beta < \frac{b_c}{h(1)}$.

With $\beta > \max\{\frac{\rho(a_c + b_c) + \delta a_c}{h(\rho) + g(\rho)}, \frac{\rho b_c}{h(\rho)}\}$, Statement i) and ii) follow straightforwardly.

Also note that $\beta < \frac{b_c}{h(1)}$ and $\beta > \max\{\frac{\rho(a_c + b_c) + \delta a_c}{h(\rho) + g(\rho)}, \frac{\rho b_c}{h(\rho)}\}$ derive $\frac{\rho b_c}{h(\rho)} < \beta < \frac{b_c}{h(1)}$, which implies $\theta < 1$, Statement iii).

Note $a_c + b_c - \beta(h(1) + g(1)) < 0$ and $b_c - \beta h(1) > 0$ also derive $\frac{a_c + b_c}{h(1) + g(1)} < \beta < \frac{b_c}{h(1)}$, which is equivalent to $\frac{a_c}{b_c} < \frac{d}{e}$.

Case 2. This case requires $b_c - \beta h(1) > 0$, $a_c + b_c - \beta(h(1) + g(1)) > 0$, and $\frac{b_c - \beta h(1)}{a_c + b_c - \beta(g(1) + h(1))} > \frac{b_c}{a_c + b_c}$. The requirement needs straightforwardly $\beta < \frac{b_c}{h(1)}$.

With $\beta > \max\{\frac{\rho(a_c + b_c) + \delta a_c}{h(\rho) + g(\rho)}, \frac{\rho b_c}{h(\rho)}\}$, Statement i) and ii) follow straightforwardly.

Note that $\beta < \frac{b_c}{h(1)}$ and $\beta > \max\{\frac{\rho(a_c + b_c) + \delta a_c}{h(\rho) + g(\rho)}, \frac{\rho b_c}{h(\rho)}\}$ derive $\frac{\rho b_c}{h(\rho)} < \beta < \frac{b_c}{h(1)}$, which is equivalent to $\theta < 1$, Statement iii).

Also, given $a_c + b_c - \beta(h(1) + g(1)) > 0$ and $b_c - \beta h(1) > 0$,

$$\frac{b_c - \beta h(1)}{a_c + b_c - \beta(g(1) + h(1))} > \frac{b_c}{a_c + b_c} \Rightarrow \frac{a_c}{b_c} < \frac{d}{e}. \tag{A.4}$$

The analysis above already prove the three statements and one direction in the equivalence between "In Eq. (A.3) holds for any $q \in [0, \frac{b_c}{a_c + b_c})$" and "$\beta < \frac{b_c}{h(1)}$ and $\frac{a_c}{b_c} < \frac{d}{e}$." Now we prove the other direction in the equivalence:

Reverse Case 1. $b_c - \beta h(1) > 0$, $\frac{a_c}{b_c} < \frac{d}{e}$, and $a_c + b_c - \beta(h(1) + g(1)) < 0$ derives that In Eq. (A.3) holds for all $q \in [0, \frac{b_c}{a_c + b_c})$:

$b_c - \beta h(1) > 0$ means $q[a_c + b_c - \beta(g(1) + h(1))] < b_c - \beta h(1)$ holds for $q = 0$. $a_c + b_c - \beta(h(1) + g(1)) < 0$ means $q[a_c + b_c - \beta(g(1) + h(1))]$ is decreasing in q, so $q[a_c + b_c - \beta(g(1) + h(1))] < b_c - \beta h(1)$ holds for all $q \in [0, \frac{b_c}{a_c + b_c})$.

Reverse Case 2. $b_c - \beta h(1) > 0$, $\frac{a_c}{b_c} < \frac{d}{e}$, and $a_c + b_c - \beta(h(1) + g(1)) > 0$ derives that In Eq. (A.3) holds for all $q \in [0, \frac{b_c}{a_c + b_c})$:

$a_c + b_c - \beta(h(1) + g(1)) > 0$ means $q[a_c + b_c - \beta(g(1) + h(1))]$ is increasing in q. Now consider the situation where $q = \frac{b_c}{a_c + b_c}$. In this situation, $q[a_c + b_c - \beta(g(1) + h(1))] = \frac{b_c}{a_c + b_c}[a_c + b_c - \beta(g(1) + h(1))]$. Note $\frac{a_c}{b_c} < \frac{d}{e}$ is equivalent to $\frac{b_c}{a_c + b_c}[a_c + b_c - \beta(g(1) + h(1))] < b_c - \beta h(1)$, so $q[a_c + b_c - \beta(g(1) + h(1))] < b_c - \beta h(1)$ holds for all $q \in [0, \frac{b_c}{a_c + b_c})$.

Collecting the two reverse cases finishes the proof of Proposition 4.

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