

Machiavellian Experimentation*

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Abstract

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 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.

Keywords: Politics of policy innovation; policy experimentation; heterogeneous beliefs; gridlock; Chinese transition; Operation Market Garden

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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.

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. 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; Hirsch, Forthcoming). This is the case because, when a policy prescription is new, people know very little about it, and are very likely to have different ideas about whether it will work. 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).¹

Consensus requirement. Any adoption of the policy requires consensus; otherwise, nothing will happen. In other words, both players can veto any adoption.² 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 require 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.

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

¹The theoretical tradition following Aumann (1976) denies agreeing to disagree. For supportive theories toward relaxing the common prior assumption, see Morris (1995) and Gul (1998). For examples of papers breaking the common prior assumption, see Van den Steen (2002), Che and Kartik (2009), and Hirsch (Forthcoming).

²In our model, because a default do-nothing option is always available for both players, there is no difference between unanimous agreement and unanimous consent.

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 politicians 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 basic 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 simple: 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.

By comparative statics analysis, we show how the solution to the model is affected by the magnitude of the contingent, mutually exclusive payoffs and the extent to which the players care about these payoffs. We then analyze the 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 is undesirable when the priors are only slightly different. We further show the robustness of our main result when we extend the analysis of mutually exclusive payoffs to the Big Bang approach.

After the theoretical analysis, we will apply this 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 Acemoglu and Robinson (2012

exclusive payoffs to the Big Bang approach. Section 8 illustrates the model with the two historical examples. Section 9 concludes the paper by discussing broader applications of our key logic.

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 story and our story are apparently similar but fundamentally different. In their story, given that the predecessor will lose power, she experiments in order to influence the information that the successor will face. In our story, 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 (Forthcoming) 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. Behind this idea is the literature on heterogeneous beliefs in organizations (e.g., Van den Steen, 2002, 2010a,b; Che and Kartik, 2009), which demonstrates that heterogeneity encourages players to try to convince others. Again, our idea is essentially different. In our story, 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 story 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.

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,b, 1995; Coricelli and Milesi-Ferretti,

³Callander 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.”

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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, Forthcoming). 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.⁴ 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; Keller et al., 2005; Keller and Rady, 2010; Volden et al., 2008; Strulovici, 2010; Klein, 2013; Millner et al., 2014; Callander and Harstad, 2015; Heidhues et al., 2015). Klein and Rady (2011) introduce negatively

policy that is indeed effective. 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.⁶

Fourth, the logic that people acquire information when they are confident of receiving the information that will support their position is, of course, not rare 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.

⁶Midjord et al. (2015) consider a negative disesteem payoff in the spirit of Levy (2007a,b).

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, and the players do not know the objective probability with which the policy is good. The players have their own priors about whether the policy is good: 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 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.⁷ 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.

We set the payoff structure as follows:

If they agree to 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 $-b_i < 0$.

⁷The results derived in this setting can also be achieved by non-cooperative games with complete information, and the core including both the Big Bang and the experimental approaches will be refined into a single solution favored by the first mover. For an example of these non-cooperative games, see Appendix A.1. For robustness we use the cooperative-game setting in the main text.

If they agree to 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 $0 < \delta < 1 - \rho$.⁸ If the experiment's result shows the policy is bad, then they stop the adoption, and each player gets $-\rho b_i$.

If one of the players chooses 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 shall 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.⁹

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

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 shall 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

⁸We simplify the idea that $\delta = \frac{1}{1+r}(1 - \beta)$, where β is the discount rate.

⁹For simplicity, we set the payoffs as a linear function in $\alpha \in \{0, 1\}$, 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 ($\alpha = 1$), the expected mutually inclusive payoff for the reformer is $\alpha r(1) - (1 - \alpha) r(1)$; when the adoption follows the experimental approach ($\alpha = \rho$), the expected payoff for the reformer is $[\alpha r(\rho) + \frac{1}{1+r} \alpha r(1 - \rho)] - (1 - \alpha) r(\rho)$; when there is no adoption at all ($\alpha = 0$), the payoff for the reformer is 0. For the conservative, similar payoffs follow. Also assume that $r(\cdot)$, $c(\cdot)$, $r(\cdot)$, and $c(\cdot)$ are all increasing and are equal to 0 when $\alpha = 0$. This generalization does not affect our results.

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.

For the reformer, we define the three break-even priors A_r , B_r , and C_r by

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

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). It is also obvious that $A_r > B_r > C_r$.¹⁰ Similarly, we define the three indifference values of the conservative's prior as A_c , B_c , and C_c .

With the definition of the indifference priors, we proceed with Proposition 1, the main result of this section.¹¹

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 $C_c < q < A_c$.

¹⁰If $p > A_r$, 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.

¹¹For simplicity, we consider only the cases in which A_r and A_c are not equal to any of the indifference values.

Appendix A.2 proves Proposition 1. The intuition of Proposition 1 is straightforward. 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 will 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 adopted if both players expect higher payoffs in

Figure 1 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.

If the players agree to 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 $\beta \in [0, \infty]$.

More realistically, 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 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 $(B_r < p \leq 1 \text{ and } 0 \leq q < B_c)$. 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, where we use an indicator function, $f(p, q)$, to represent the assumption about “effectiveness.”

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

Player	Big Bang approach	Experimental approach	Doing nothing
Reformer	$r - (1 -) r$	$[r + \delta r + \beta ()] - (1 -) [r + \beta ()]$	0
Conservative	$c - (1 -) c$	$[c + \delta c - \beta ()] - (1 -) [c - \beta ()]$	0
$() = 1 \text{ if } \in \left(\frac{b_r}{a_r + b_r}, 1 \right] \text{ and } \in \left[0, \frac{b_c}{a_c + b_c} \right); \text{ otherwise } () = 0.$			

Now we analyze the model with effective mutually exclusive payoffs, 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 are possible only with the experimental approach, and therefore they 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. For the conservative and the reformer, we respectively define the break-even priors D and E , with which they would be indifferent between an experimental approach and doing nothing when the mutually exclusive payoffs are effective, as follows:

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

With the two newly-introduced indifference priors, we proceed with Proposition 2, the main result of this section and this paper.¹³

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 con-*

¹³For simplicity, we only consider the cases in which a_r and a_c are not equal to any of the indifference priors.

tin ent, mutually exclusive payoffs are effective. Further assume the players care stron ly about these contin ent, mutually exclusive payoffs. Then the followin two statements are true:

i) If the conservative holds a sufficiently stron 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 $\beta > \max \left\{ \frac{\rho(a_c+b_c)+\delta a_c}{e+d}, \frac{\rho b_c}{e} \right\}$. Then the followin 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 straightforward. 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 ($\beta > \max \left\{ \frac{\rho(a_c+b_c)+\delta a_c}{e+d}, \frac{\rho b_c}{e} \right\}$), 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.

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

conservative's approval for any policy change, including an experimental implementation of the new policy, will remain.

Extending the model from two to N players would demonstrate a more significant role of the contingent, mutually exclusive payoffs. A newly introduced, moderate reformer could veto a formerly agreed experimentation, because she would be afraid of being proven incorrect and therefore being punished. As the extension adds little intuition, we leave it to Appendix A.4.

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 ($\beta > \max\left\{\frac{\rho(a_c+b_c)+\delta a_c}{e+d}, \frac{\rho b_c}{e}\right\}$), 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 Figure 1, 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 Figure 1, 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 Figure 2, 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 Figure 2, 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 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 Figure 2, and how the weight of the mutually exclusive payoffs, β , changes the solution pattern of the shaded area.¹⁴

5.1 The Impact of the Magnitude of the Mutually Exclusive Payoffs

Assume $\beta > \max \left\{ \frac{\rho(a_c + b_c) + \delta a_c}{e + d}, \frac{\rho b_c}{e} \right\}$. By Equation (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 .¹⁵ Note that in Figure 2, 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, Equation (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.

¹⁴The comparative statics around the experimental scale, β , is less straightforward, so we do not detail it here. The main point is, that the monotonicity of β with respect to β is ambiguous, although β is monotonically increasing in β , which means the monotonicity of the size of the area of interest in β is ambiguous.

¹⁵If $\beta > \frac{\rho(a_c + b_c) + \delta a_c}{e + d}$ and $\beta > \frac{\rho b_c}{e}$, then the entire shadowed area in Figure 2 is occupied by the experimental approach.

5.2 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 ($\beta < \max \left\{ \frac{\rho(a_c+b_c)+\delta a_c}{e+d}, \frac{\rho b_c}{e} \right\}$). Appendix A.3 details the solutions to the model with different β .

If the players care little about the mutually exclusive payoffs ($\beta < \min \left\{ \frac{\rho(a_c+b_c)+\delta a_c}{e+d}, \frac{\rho b_c}{e} \right\}$), then the model solution, as illustrated in Figure 3, should be similar to the case with only mutually inclusive payoff, as illustrated in Figure 1. 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.

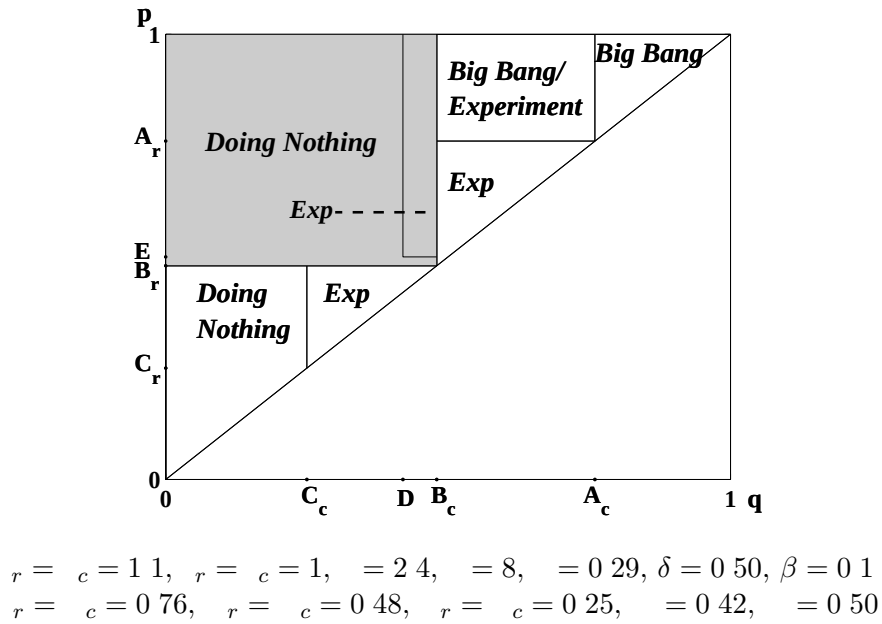


Figure 3: The typical case with small β

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. Figure 4 illustrates the case, in which “Doing Nothing” occupies the entire shaded area.

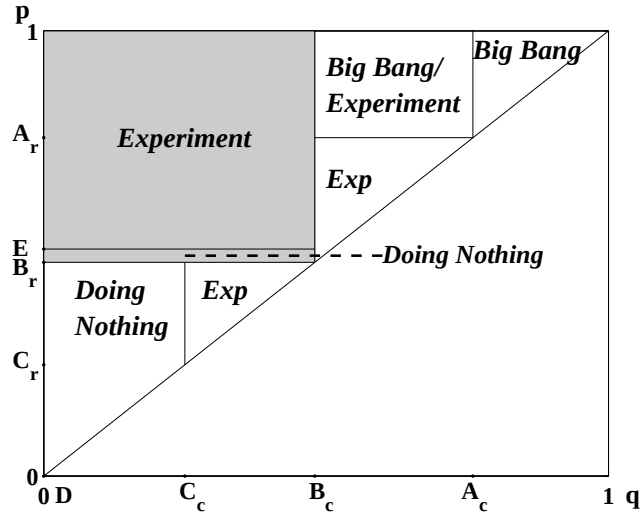
In the second case, we have $-\rho b_c + \beta e < \rho a_c + \delta a_c - \beta d$ and $-\rho b_c + \beta e > 0$. The inequalities imply that the conservative prefers a successful experiment to a failed one, and even a failed experiment is better than doing nothing. She will then always prefer the

$$r = c = r = c = 2, \quad = 1, \quad = 5, \quad = 0.25, \delta = 0.50, \beta = 0.4$$

$$r = c = 0.75, \quad r = c = 0.5, \quad r = c = 0.25, \quad = -0.25, \quad = 0.57$$

Figure 4: One typical case with moderate β

experimental approach to doing nothing, even when her prior q approaches zero. Now whether to adopt the experimental approach depends on the reformer decision. One typical situation with $E > B_r$ is illustrated by Figure 5, 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 $B_r < p < E$.



$$r = c = 1.1, \quad r = c = 1, \quad = 1, \quad = 2.6, \quad = 0.33, \delta = 0.50, \beta = 0.34$$

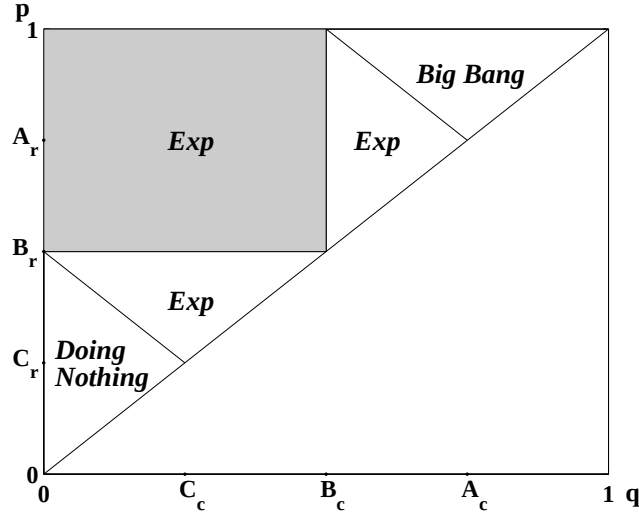
$$r = c = 0.78, \quad r = c = 0.48, \quad r = c = 0.27, \quad = -0.53, \quad = 0.51$$

Figure 5: Another typical case with small β

6 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 payoffs.

For simplicity, we assume that the mutually inclusive payoff is symmetric across the players, which means a_r



$$r = c \equiv 2, \quad r = c \equiv 0.25, \quad \delta = 0.50$$

$$r = c \equiv 0.75, \quad r = c \equiv 0.5, \quad r = c \equiv 0.25$$

Figure 6: An example of the decision of the organizational planner

where the players care strongly about the mutually exclusive payoffs. Comparing Figures 1 and 6, 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 Figures 2 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.¹⁷

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

¹⁷For aesthetic simplicity, the specification in Figure 6 makes $r = c \equiv 2 - 1$, which is not universally true. The discussion always holds, however, because

7 Robustness: Extending the Contingent, Mutually Exclusive Payoffs to 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 $\theta > 0$.¹⁸

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

¹⁸This functional form is assumed to investigate the return to scale of the mutually exclusive payoffs.

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 3 shows the expected payoff from the two approaches and doing nothing when the extended mutually exclusive payoffs are effective.

Table 3: 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	$[r + \beta(1)] - (1 - \beta)[r + \beta(1)]$	$[r + \delta_r + \beta(1)] - (1 - \beta)[r + \beta(1)]$	0
Conservative	$[c - \beta(1)] - (1 - \beta)[c - \beta(1)]$	$[c + \delta_c - \beta(1)] - (1 - \beta)[c - \beta(1)]$	0
In the case of $\beta = 1$, i.e. $\beta \in \left(\frac{b_r}{a_r + b_r}, 1\right]$ and $\beta \in \left[0, \frac{b_c}{a_c + b_c}\right)$.			

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

$$D' = \frac{\rho b_c - \beta h(\rho)}{\rho a_c + \delta a_c + \rho b_c - \beta(h(\rho) + g(\rho))}, \quad E' = \frac{\rho b_r + \beta g(\rho)}{\rho a_r + \delta a_r + \rho b_r + \beta(h(\rho) + g(\rho))}. \quad (6)$$

With the two newly-introduced indifference priors, we proceed with Proposition 3.¹⁹

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 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 $\beta > \max\left\{\frac{\rho(a_c + b_c) + \delta a_c}{h(\rho) + g(\rho)}, \frac{\rho b_c}{h(\rho)}\right\}$, 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.*

¹⁹For simplicity, we only consider the cases in which β and β are not equal to any of the indifference priors.

- ii) If $D' < q < B_c$ or $B_r < p < E'$, then the policy will not be adopted.
- iii) $\theta < 1$.

Appendix A.7 proves Proposition 3. The intuition is simple. 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 2.²⁰ When the players strongly care about the extended mutually exclusive payoffs ($\beta > \max \left\{ \frac{\rho(a_c + b_c) + \delta a_c}{h(\rho) + g(\rho)}, \frac{\rho b_c}{h(\rho)} \right\}$), 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 prefer 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.

8 Two Historical Illustrations

8.1 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

²⁰The simple expression of the relative size relies on the specification of $\beta(\cdot) = \frac{\rho(a_c + b_c) + \delta a_c}{h(\rho) + g(\rho)}$ and $\gamma(\cdot) = \frac{\rho b_c}{h(\rho)}$. Other specifications, for example, a linear specification of $\beta(\cdot)$ and $\gamma(\cdot)$, will not derive the same simple expression, but still carry the same intuition.

Plan, a Soviet-style scientific economic plan.²¹ 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* (February 25, 1989).²² 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.²³

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. 741)’s short biography of Chen Yun,

²¹The 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.

²²Li 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.

²³Shirk (1993, 1994) thoroughly documents the political issues around the Chinese transition before the early 1990s. Zhao (2009b, Vol. 3, Ch. 1) documents in detail the differences between the leaders’ ideas about the Chinese economy. Xu (2011) cites Deng Xiaoping (1984), Li Rui (2008), Bao Tong (2009), and Zhao Ziyang (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.”

“On important issues relating to the economy, ideology, Party organization, and basic Party Policy, it was expected that Deng would seek the approval or at least the acquiescence of Chen Yun.”²⁴ The metaphor created by Yang (2004) to describe this equilibrium, the *two-peak politics* (*shuan fen zhen zhi*), 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’ beliefs 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 Yun (1995) emphasized in 1980 that “the mainstay of our country is a planned economy.”²⁵ 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 Ziyang (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.²⁶

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.

²⁴In 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 and ratified the new direction laid out at the work conference, Deng Xiaoping, aged 74, sat on the podium with Chen Yun, aged 73.”

²⁵The 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.

²⁶In 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.

As Woo (1994, p. 279), Roland (2000, p. 36–37), Cai and Treisman (2006), and Xu (2011) have suggested, China’s adoption of the experimental approach might result from the presence of diametrically opposite beliefs toward the reform. Our Proposition 2 supports this explanation: 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 answer 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.²⁷ For example, Vogel’s biography of Deng Xiaoping (2011, p. 420) notes, “if something was working, that policy or that person garnered support,” “if something was failing, however, people began to move away and to shun the failure,” 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.²⁸

Shirk (1993) also observes that, in most cases, when an experimental approach was adopted, both factions used their political resources to tilt the experiment toward the outcome they desired. These tactics suggest the significance of contingent, mutually exclusive payoffs because, otherwise, both factions should hope for a fair experiment through which unbiased information would be revealed.

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

²⁷There is a phrase *zhengzhi ziben* for this kind of political power in Chinese. A straight English translation would be *political capital*.

²⁸In 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.

²⁹Vogel (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

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. An important alternative explanation, following the logic in Hirsch (Forthcoming), 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 (2009b, Vol. 3, Ch. 3), 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 story. 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 story 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. To bolster our argument, we now discuss a specific, concrete experimental reform:

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.”

³⁰We 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 should be simple: 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 either Proposition 2 or 3 is applicable.

The generalization of the household-responsibility system. Beginning in 1955, China adopted a system of collectivized agriculture. As early as 1977, some remote, starving rural areas began to decentralize agricultural production and adopt the household-responsibility system (*baochan daohu*). Adopting the new system on a broader level, however, was explicitly prohibited by the Central Committee of the Communist Party of China in 1979.

As Zhao Ziyang (2009b, p. 136–138) documents, in the wake of major success of the reform in starving rural areas, a fierce debate erupted over whether to generalize the reform to the whole country. Within the Central Committee of the Party, the conservative group, represented by Hua Guofeng, Li Xiannian, Chen Yonggui, Wang Renzhong, Hu Qiaomu, and Xu Xiangqian, strongly and publicly opposed the reform on the grounds of ideology, amid concerns about decreasing the scale of agricultural production. This standpoint reflected an extreme conservative belief. In contrast, the reformer group, represented by Deng Xiaoping, Chen Yun, and Wan Li, emphasized the existing success in rural areas, and insisted on generalizing the reform.³¹ As readers who are familiar with Chinese history well know, both factions were politically strong, and each could actually veto any proposal if the other insisted on its position.³²

Moreover, there was also a huge debate among provincial leaders and within the State Agriculture Commission. To discuss whether to generalize the reform, the Central Committee of the Party scheduled a colloquium for provincial officials in September 1980. As recollected by Du Runsheng (2005, p. 117–118), who was the lowest ranked vice director of the State Agriculture Commission at the colloquium, he first presented his support for the generalization, but the Commission then stated that it did not support his position. There was also no unanimous view from provincial officials.³³ Du Runsheng (2005, p. 119) and Zhao Ziyang (2009b, Vol. 3, Ch. 10) both report that the divergence was so huge that neither side could persuade its opponent to change the position. Then came one of the most famous exchanges during Chinese transition:

You can go your broad way as you want, but I shall definitely go my way,

³¹Vogel (2011, p. 467–476) describes the formation of the reformer group, and Zhao Ziyang (2009b, p. 136–138) lists the names of the leaders who held the conservative view about this specific issue.

³²The conservative figures were huge in the context: apart from Li Xiannian and Hu Qiaomu whom we have already introduced in Footnote 21, Hua Guofeng was Mao Zedong’s designated successor as the paramount leader of the Party and the country; Xu Xiangqian was the second ranked of the only four Marshals alive at the time, among the Ten Marshals who were the most important military leaders; Chen Yonggui and Wang Renzhong were the directors of agriculture in the government.

³³Du Runsheng (2005, p. 118) and Wu (2012) document that many of them, such as those from Heilongjiang, Jiangsu, Fujian, Shaanxi, and Hebei Provinces, strongly opposed the generalization. Three others, from Guizhou, Inner Mongolia, and Liaoning, strongly favored the proposal.

even if you think I am crossing a giant canyon via only a single plank!³⁴

The exchange suggested that the two factions agreed to disagree and were extremely confident of being proven correct in the future. At the end of the meeting, the Central Committee of the Party (1980) released Directive No. 75. This Directive formally allowed provincial governments to decide whether to adopt the household-responsibility system. Given that the Central Committee of the Party knew from the colloquium exactly which provinces would adopt the system and which would not, the Directive basically introduced an experimental approach to the reform across different Chinese provinces, with some adopting it and some not.

Given that the conservatives were strongly opposed to the reform not only at the central government level but also at the provincial level, how could the experimental approach have been adopted? Proposition 2 suggests that its adoption could have been driven by the presence of diametrically opposite beliefs coexisting with significant mutually exclusive payoffs. This speculation is supported by strong *ex post facto* evidences. For example, as mentioned by Du Runsheng (2005, p. 130–132), as the success of the experimental reform was realized, several provincial leaders who had been opposed to the reform were removed from their posts. The State Agriculture Commission, whose ministers (except Du Runsheng) had opposed the reform, was displaced in 1982 by the Division of Rural Policy Research of the Central Committee of the Party and the Center of Rural Development Research of the State Council, which were directed by Du Runsheng (Du Runsheng, 2005, p. 117).³⁵ It is also fair to say that the success of the reform also helped to promote its strongest advocates, e.g., Zhao Ziyang and Wan Li, and to accelerate the retirement of several prominent conservatives, e.g., Hua Guofeng and Chen Yonggui, from the core of Chinese politics.³⁶ These observations also hint that it would be difficult to argue that the mutually exclusive payoffs did not play a role in the experimental generalization of the household-responsibility system.

³⁴In Chinese, the saying reads *Ni zou nide yangguandao, wo zou wode dumuqiao*. Du Runsheng (2005, p. 119) and Zhao Ziyang (2009b, p. 137) document this exchange between Yang Yichen, the First Party Secretary of Heilongjiang Province, who rejected the household-responsibility system, and Chi Biqing, the First Party Secretary of Guizhou Province, who supported the household-responsibility system.

³⁵In Chinese, the Division of Rural Policy Research of the Central Committee of the Party is *Zhonggong Zhongyang Nongcun Zhengce Yanjiu Shi*, and the Center of Rural Development Research of the State Council is *Guowuyuan Nongcun Fazhan Yanjiu Zhongxin*. Du Runsheng would later become one of the most influential and respected leaders of Chinese rural reform. As a disclaimer, we are not suggesting that Du Runsheng was manipulating in the policy debate for his own promotion or reputation. On the contrary, we deeply respect Du Runsheng, for his devotion to rural reform in China, which has shown his unquestionably exceptional character. Our argument, however, applies to the two groups of leaders in the debate.

³⁶In June 1981, Hua Guofeng resigned as the Chairman of the Party, while Zhao Ziyang was promoted to become Vice Chairman of the Party. In 1982, Wan Li was promoted to the First Secretary of the 12th Central Committee of the Party, while Chen Yonggui retired from the Committee.

Finally, the plausibility of our explanation is also supported by Du Runsheng (2005, p. 118–119)’s remark summarizing the policymaking process. He said:

The opinions were too opposite for the colloquium to continue. ... Directive No. 75 was a compromise result from the debate.

Based on this quote and the earlier “broad way versus single plank” exchange, it is crystal clear that the Directive was a compromise result that was reached because neither of the two factions would compromise, and that the adoption of the experimental approach resulted from the diametrically opposite beliefs and the huge expectations of being proven correct.

8.2 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 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).³⁷ 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

³⁷Also see Murray (1996) and Baxter (1999, p. 89–100) for detailed accounts of the bibliography on this argument.

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, 1944.³⁸

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. As we all know now, this operation would, in fact, turn out to be a total disaster.³⁹ 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.”⁴⁰ 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

³⁸For details about the meeting, see Ambrose (1990, p.163) and D’Este (2002, p. 605–606).

³⁹Coble (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.

⁴⁰Montgomery was nicknamed “Monty,” while Eisenhower was nicknamed “Ike.”

heavy, this explanation cannot convince historians like Baxter (1999, p. 95), D’Este (2002, p. 603), and Ambrose (2012, p. 557).⁴¹ 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).⁴² 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. 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 representatives of the American and British interests in the political competition.⁴³ 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,

⁴¹As quoted by Baxter (1999, p. 95) and D’Este (2002, p. 603), Ambrose (2012, p. 557) states that “Eisenhower could not make his decisions solely on military grounds.”

⁴²Ambrose (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.

⁴³See documentation of many historians, e.g., David Eisenhower (1986, p. 445), D’Este (2002, p. 603), Ambrose (2012, Ch. 12–13), and the references in Baxter (1999, p. 95).

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. 557) 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, any more than he would agree to give it to American forces."⁴⁴ 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."⁴⁵ 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

⁴⁴D'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."

⁴⁵General 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."

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.”⁴⁶ 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.”⁴⁷ As noted by D’Este (2002, p. 618), Montgomery scapegoated General 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.”⁴⁸ 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.”⁴⁹ For Eisenhower, the Anglo-American balance within the leadership of the Allied Forces became more stable, and the Allied (and the American) interests were better secured. These observations also support our

⁴⁶Coble (2009, p. 32) also comments that “Eisenhower sacrificed an Allied division to allow Montgomery to prove” that the single-thrust strategy was wrong.

⁴⁷Montgomery (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.”

⁴⁸Eisenhower (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.”

⁴⁹The CCS is the abbreviation of the Combined Chiefs of Staff for the western Allies. Ambrose (2012, p. 578) 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 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.

story over a competing explanation, along the line of Hirsch (Forthcoming), 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 our model well fits the setting, prediction, and logic of the Eisenhower–Montgomery dispute about and the decision concerning Operation Market–Garden.

9 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,b), intra-group 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, following the approach in Rausser et al. (2011, Ch. 18).

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

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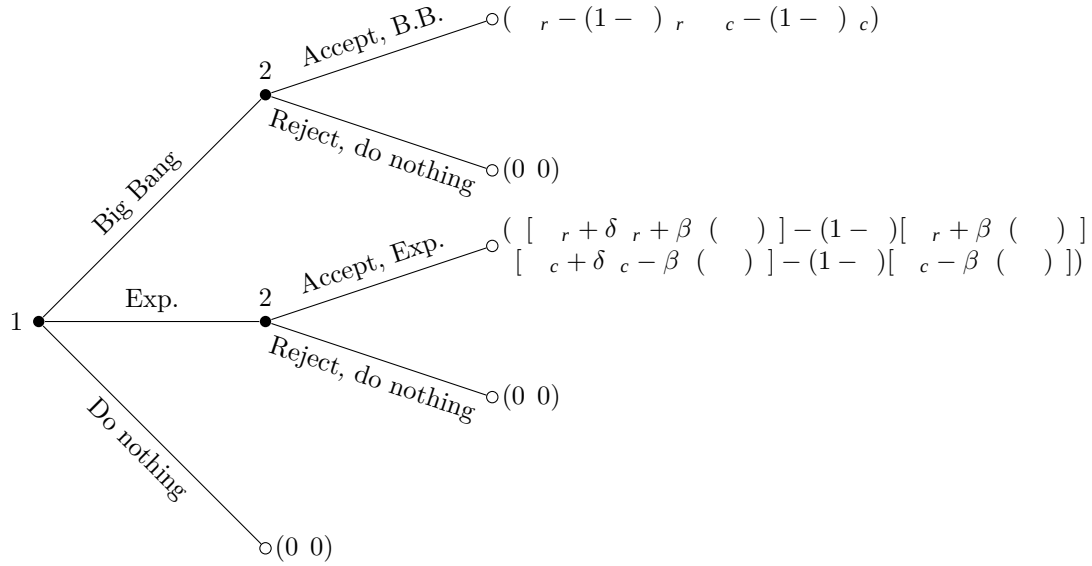
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A Appendices

A.1 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. 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. Figure 7 shows the extensive form of this game.



1: Reformer; 2: Conservative. $(\cdot) = 1$ if $\alpha_r \in \left(\frac{b_r}{a_r + b_r}, 1\right]$ and $\alpha_c \in \left[0, \frac{b_c}{a_c + b_c}\right)$; otherwise $(\cdot) = 0$.

Figure 7: The extensive form of the non-cooperative 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.

A.2 Proof of Proposition 1

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.

A.3 Proof of Proposition 2

Consider $f(p, q) = 1$, which yields $p \in \left(\frac{b_r}{a_r+b_r}, 1\right]$ and $q \in \left[0, \frac{b_c}{a_c+b_c}\right)$. Also assume $\beta > \frac{\rho(a_c+b_c)+\delta a_c}{e+d}$.

The experimental approach will be adopted if, and only if,

$$\begin{aligned} p(\rho a_r + \delta a_r + \beta e) - (1-p)(\rho b_r + \beta d) &> 0 \text{ and} \\ q(\rho a_c + \delta a_c - \beta d) - (1-q)(\rho b_c - \beta e) &> 0. \end{aligned} \tag{7}$$

Otherwise nothing will be done.

Proposition 2 is then proved by some algebra.

A.4 Extension: Contingent, Mutually Exclusive Payoffs with N Players

In this section, we generalize the model with contingent, mutually exclusive payoffs for N players, where $N \geq 2$. We shall show that the result in Section 4 still hold. The model in Section 4 is simply a special case for the discussion in this section with $N = 2$. We shall also show that the role of contingent, mutually exclusive payoffs becomes more significant when more players participate in decision-making process.

We employ the same model structure and model settings as described in Section 2. The N players come together to discuss whether and how the organization should adopt a policy. Each player believes the policy has a probability p_i ($i = 1, 2, \dots, N$) to be good. There are still three options for the decision: adopting the policy in a Big Bang approach, adopting the policy in an experimental approach, and doing nothing. The first two approaches require consensus from the N players, in the sense that any of them could choose doing nothing as she wants.

The mutually inclusive payoff and the break-even priors A_i , B_i , and C_i for each player are defined in the same way as in Section 3.⁵⁰ We label the players with $B_i < p_i \leq 1$ *reformers*, and those with $0 \leq p_i < B_i$ *conservatives*.⁵¹ Each player is then either a reformer or a conservative. The corresponding contingent, mutually exclusive payoffs are defined as follows:

If the N players agree to the experimental approach: If the experiment's result shows the policy is good, then the reformers get $f(p_1, p_2, \dots, p_N)e$, while the conservatives get $-f(p_1, p_2, \dots, p_N)d$, where $d > 0$ and $e > 0$. If the experiment's result shows the policy is bad, then the reformers get $-f(p_1, p_2, \dots, p_N)d$, while the conservatives get

$f(p_1, p_2, \dots, p_N)e$. The indicator function $f(p_1, p_2, \dots, p_N)$ shows whether the payoff structure is effective, where $f(p_1, p_2, \dots, p_N) = 1$ if there are at least one reformer and one conservative; otherwise, $f(p_1, p_2, \dots, p_N) = 0$.⁵²

Consistent with Section 4, we assume that players value the contingent, mutually exclusive payoffs with a weight β over the mutually inclusive payoff, where $0 \leq \beta \leq +\infty$. Similarly, the adoption of policy in any approach requires: this approach brings positive weighted sum of the expected mutually inclusive and mutually exclusive payoffs to the N players, and the other approach cannot give all the players higher weighted sum of the expected mutually inclusive and mutually exclusive payoffs than this approach does.⁵³

With a similar argument, the break-even priors D_i for the reformers and E_j for the conservatives are respectively defined for the trade-off between an experimental approach and doing nothing.⁵⁴ With the definition of the indifference priors, we proceed with Proposition 4.

Proposition 4. *Label the players who prefer the Bi Ban approach to doin nothin the reformers, and those who prefer doin nothin to the Bi Ban approach the conservatives, when considerin only the mutually inclusive payoff. Assume there are at least one reformer and one conservative. Then contin ent, mutually exclusive payoffs are effective. Further assume the players stron ly care about the contin ent, mutually exclusive payoffs. Then the followin two statements are true:*

- i) If all of the conservatives sufficiently disbelieve in the policy while the reformers sufficiently believe in the policy, then the experimental approach will be adopted.*
- ii) Otherwise, the policy will not be adopted.*

Mathematically and more precisely, define sets $\phi \equiv \{i : B_i < p_i \leq 1, i = 1, 2, \dots, N\}$ and $\varphi \equiv \{j : 0 \leq p_j < B_j, j = 1, 2, \dots, N\}$. Assume $\phi \cup \varphi = \{1, 2, \dots, N\}$, $\phi \neq \emptyset$, and $\varphi \neq \emptyset$. Then $f(p_1, p_2, \dots, p_N) = 1$. Further assume $\beta > \max_{j \in \varphi} \left\{ \frac{\rho(a_j + b_j) + \delta a_j}{e + d}, \frac{\rho b_j}{e} \right\}$. Then the followin two statements are true:

- i) If $0 \leq p_j < \min \{D_j, B_j\}$ for any $j \in \varphi$ and $\max \{B_i, E_i\} < p_i \leq 1$ for any $i \in \phi$, then the experimental approach will be adopted.*
- ii) If $\exists j \in \varphi$ such that $D_j < p_j < B_j$ or $\exists i \in \phi$ such that $B_i < p_i < E_i$, then the policy will not be adopted.*

Proposition 4 comes from both the contingent, mutually exclusive payoffs and the consensus requirement. The intuition and results are very similar to Proposition 2 in Section 4. More details can be found in Appendix A.5. Another interesting observation is that, if all the players hold identically, independently, and uniformly distributed priors, then it is more likely for opposite ideas to exist with newly-added players, and furthermore, when the number of players increases, the mutually exclusive payoffs are even more likely to be

⁵²In this setting, contingent, mutually exclusive payoffs capture the different voices across all the players, and they are effective if, and only if, there exists sufficiently different views toward the policy. In other words, there should be at least one player who prefers the Big Bang approach to doing nothing, and another player who prefers doing nothing to the Big Bang, for the mutually exclusive payoffs to be effective.

⁵³For simplicity, we ignore the break-even cases.

⁵⁴More specifically, $i = \frac{b_i - e}{a_i + a_i + b_i - (e + d)}$ and $j = \frac{b_j + d}{a_j + a_j + b_j + (e + d)}$.

effective. As an example, Appendix A.6 details the evolution of the outcome structure when we introduce a third player to the two-player model.

A.5 The Intuition of Proposition 4

When the mutually exclusive payoffs are effective, players can be split into two groups, one regarded as reformers and the other as conservatives. To be noted, the conservatives always prefer doing nothing over the Big Bang approach, and thus the Big Bang approach will never be adopted. In this case, if the conservatives sufficiently disbelieve in the policy ($\forall j \in \varphi, 0 \leq p_j < \min\{D_j, B_j\}$), then they will regard that they are sufficiently likely to be proved correct in an experimental approach, and thus gain positive mutually exclusive payoffs from the experimental approach. Furthermore, if they sufficiently care about the mutually exclusive payoffs ($\beta > \max_{j \in \varphi} \left\{ \frac{\rho(a_j + b_j) + \delta a_j}{e + d}, \frac{\rho b_j}{e} \right\}$), then the mutually exclusive-payoff consideration will dominate their mutually inclusive payoff consideration about the experimental approach, and they will prefer the experimental approach over doing nothing. On the other hand, the experimental approach still will not be adopted if any of the reformers does not sufficiently believe in the policy ($\exists i \in \phi, B_i < p_i < E_i$), since she will be afraid of losing too much in the experimental approach, and the expected loss will threat her to prefer doing nothing over the experimental approach. Therefore, the experimental approach will be adopted only if all of the N players have opposite and sufficiently extreme priors; otherwise, no policy will be adopted.

To illustrate Proposition 4, Figure 8 shows the solution to a game with $N = 3$. In Figure 8, the mutually exclusive payoffs are effective near the six cube vertices except $(0, 0, 0)$ and $(1, 1, 1)$.⁵⁵ When the mutually exclusive payoffs are effective, the Big Bang approach cannot be reached as an outcome because of the requirement of consensus. Under this situation, the conservative always regard doing nothing better than the Big Bang approach, and will thus veto the Big Bang approach. On the other hand, as Proposition 4 states, given effective mutually exclusive payoff, if, and only if, each player holds extreme prior toward the policy, they will agree to an experimental approach. In other words, “experimental approach” occupied the corners of six vertices shaded by the same color, whose locations are denoted as italic “Experiment” with three in the front and three on the back.⁵⁶ Meanwhile, there is no policy adoption if any of the players hold a moderate belief toward the policy, given that the mutually exclusive payoffs are effective. In Figure 8, we can see that no policy adoption is achieved near the middle of edges.

⁵⁵The six cube vertices are $(0 \ 0 \ 1)$, $(0 \ 1 \ 0)$, $(1 \ 0 \ 0)$, $(0 \ 1 \ 1)$, $(1 \ 0 \ 1)$ and $(1 \ 1 \ 0)$.

⁵⁶Besides these six areas, there are two small areas with the experimental approach, which are located near the center of the cube, and are shaded by black. They capture the situation when there is no opposite extreme belief across players, i.e. $\neq \emptyset$ and $\neq \emptyset$ are not satisfied simultaneously. At this time, mutually exclusive payoffs do not exit in players’ consideration, and only when all of the players hold similar moderate beliefs, the experimental approach can be achieved, which corresponding to Proposition 1. In Figure 8, due to three dimensions, we can only see one of the areas from this view.

$$a_i = b_i = 2, i = 1; 2; 3, e = 1, d = 2, \quad = 0:25, \quad = 0:50, \quad = 10$$

$$A_i = 0:75, B_i = 0:5, C_i = 0:25, D_i = 0:34, E_i = 0:64$$

Figure 8: The typical case of $N = 3$ with large

A.6 Details about Extending the Two-Player Model to a Three-Player Model

We further our analysis to how introducing a third player can largely change the outcome structure of the two-player model. We first demonstrate Figure 9, which generalizes Figure 2 without assuming $p > q$. It illustrates the outcome structure of the two-player model with mutually exclusive payoffs and a large β . We then compare it with the sub games in Figure 10, showing the outcome structure of the three-player model by introducing a third player into the two-player model, given different values of Player 3's prior.⁵⁷

First of all, let's focus on when contingent, mutually exclusive payoffs are effective. For contingent, mutually exclusive payoffs to be effective, there should exist opposite ideas about the trade-off between the Big Bang approach and doing nothing. In Figure 9 and 10, the break-even prior is 0.5. We denote this prior with dotted lines, and we divide each of Figure 9 and the sub games in Figure 10 into four parts by the dotted lines. For Figure 9, the mutually exclusive payoffs are effective in the left-top part and the right-bottom part. For each of sub games 10a, 10b and 10c, since Player 3 is a conservative, mutually exclusive payoffs are ineffective in the left-bottom part among the four parts, while effective in the other three. For each of sub games 10d, 10e and 10f, since Player 3 is a reformer, mutually exclusive payoffs are ineffective in the right-top part among the four parts, while effective in the other three. Comparing Figures 9 and 10, introducing Player 3 greatly enlarges the area where contingent, mutually exclusive payoffs are effective from two parts to three parts among the total four parts. The intuition is simple: with a newly-added player, if all the players hold identically, independently, and uniformly distributed priors, it is more likely for opposite ideas to exist, and furthermore, when the number of players increases, the mutually

⁵⁷ The six sub games are cross sections of Figure 8, which include all the different possible cross sections.

$$a_1 = a_2 = b_1 = b_2 = 2, e = 1, d = 2, \quad \beta_1 = 0.25, \quad \beta_2 = 0.50, \quad \beta_3 = 10$$

$$A_1 = A_2 = 0.75, B_1 = B_2 = 0.5, C_1 = C_2 = 0.25, D = 0.34, E = 0.64$$

The areas with the experimental approach adopted and mutually exclusive payoffs effective are marked by italic \Exp"; the areas with the experimental approach adopted but mutually exclusive payoffs ineffective is marked by normal \Exp"; the areas in white denotes that the policy is not adopted.

Figure 9: The case for two players with a large

exclusive payoffs are even more likely to be effective.

In the sub figures, the areas with the experimental approach being adopted and mutually exclusive payoffs being effective are marked by italic \Exp"; the area with the experimental approach being adopted but mutually exclusive payoffs being ineffective is marked in normal \Exp". When Player 3 is very conservative toward the policy ($\beta_3 < 0.34$), as shown in Sub figures 10a and 10b, the experimental approach is reached at the area where Player 1 or Player 2 is strongly optimistic toward the policy, the area with diametrically opposite beliefs and effective mutually exclusive payoffs.

(a) Player 3: $p_3 = 0:1$

(b) Player 3: $p_3 = 0:3$

(c) Player 3: $p_3 = 0:4$

(d) Player 3: $p_3 = 0:6$

(e) Player 3: $p_3 = 0:7$

(f) Player 3: $p_3 = 0:9$

$$a_i = b_i = 2, i = 1; 2; 3, e = 1, d = 2, \quad = 0:25, \quad = 0:50, \quad = 10$$

$$A_i = 0:75, B_i = 0:5, C_i = 0:25, D_i = 0:34, E_i = 0:64$$

The areas with the experimental approach adopted and mutually exclusive payoffs effective are marked by italic \Exp"; the areas with the experimental approach adopted but mutually exclusive payoffs ineffective is marked by normal \Exp"; the areas in white denotes that the policy is not adopted.

Figure 10: Typical cases for the first two players given different p_3 , the third player's prior

dotted lines. When the mutually exclusive payoffs are ineffective, if Player 3 is a conservative ($p_3 < 0.5$), then she will always veto the Big Bang approach, and the experimental approach can only be adopted if all the players share moderate conservative beliefs; if Player 3 is a reformer ($p_3 > 0.5$), then either the experimental approach or the Big Bang approach can be achieved, since all of the players are reformers. This outcome structure with ineffective mutually exclusive payoffs follows the classic logic in Section 3.

We conclude this section by detailing the outcome change from the two-player case to the three-player case when Player 3 is strongly optimistic toward the policy ($p_3 > 0.64$). In Figure 9, the left-bottom corner of the unit square is not occupied by any approach of policy adoption: when both players are extremely conservative, the policy is not adopted. In Subfigures 10e and 10f, however, the left-bottom corners of the unit squares are occupied by “ ”: with the newly-introduced, extremely-optimistic Player 3, the extremely conservative Players 1 and 2 would like to agree to the experimental approach. We can regard such comparison as a story in which the two extreme conservatives form an ally in the sense that they gain or lose with the mutually exclusive payoffs together, and just against Player 3. This ally is contingent on the players’ priors.⁵⁹

A.7 Proof of Proposition 3

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

$$q[a_c - g(1)] - (1 - q)[b_c - h(1)] < 0; \text{ i.e. } q[a_c + b_c - (g(1) + h(1))] < b_c - h(1): \quad (8)$$

Inequation (8) derives the following Lemma.

Lemma 1. $q \in [0; \frac{b_c}{a_c + b_c}] \quad b_c - h(1) > 0$

$$a_c + b_c - (h(1) + g(1)) < 0 \in \quad a_c + b_c - (h(1) + g(1)) > 0 \quad \frac{b_c - h(1)}{a_c + b_c - (g(1) + h(1))} > \frac{b_c}{a_c + b_c}$$

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

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

With $> \max \frac{(a_c + b_c) + a_c}{h(1) + g(1)}; \frac{b_c}{h(1)}$, Statement i) and ii) follow straightforwardly.

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

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

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

⁵⁹The difference between the right-top corners of Subfigures 10e and 10f, two areas without effective mutually exclusive payoffs, is slight and depends on how optimistic Player 3 is.

With $\gamma > \max_{n \in \mathbb{N}} \frac{(a_c + b_c) + a_c}{h(n) + g(n)}; \frac{b_c}{h(n)}$, Statement i) and ii) follow straightforwardly.

Note that $\gamma < \frac{b_c}{h(1)}$ and $\gamma > \max_{n \in \mathbb{N}} \frac{(a_c + b_c) + a_c}{h(n) + g(n)}; \frac{b_c}{h(n)}$ derive $\frac{b_c}{h(n)} < \gamma < \frac{b_c}{h(1)}$, which is equivalent to $\gamma < 1$, Statement iii).

Also, given $a_c + b_c = (h(1) + g(1)) > 0$ and $b_c = h(1) > 0$,

$$\frac{b_c}{a_c + b_c} \frac{h(1)}{(g(1) + h(1))} > \frac{b_c}{a_c + b_c} \Rightarrow \frac{a_c}{b_c} < \frac{d}{e}. \quad (9)$$

The analysis above already prove the three statements and one direction in the equivalence between “Inequation (8) holds for any $q \geq 0$; $\frac{b_c}{a_c + b_c} \geq \gamma$ ” and “ $\gamma < \frac{b_c}{h(1)}$ and $\frac{a_c}{b_c} < \frac{d}{e}$.” Now we prove the other direction in the equivalence:

Reverse Case 1 $b_c = h(1) > 0$, $\frac{a_c}{b_c} < \frac{d}{e}$, and $a_c + b_c = (h(1) + g(1)) < 0$ derives that Inequation (8) holds for all $q \geq 0$; $\frac{b_c}{a_c + b_c} \geq \gamma$:

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

Reverse Case 2 $b_c = h(1) > 0$, $\frac{a_c}{b_c} < \frac{d}{e}$, and $a_c + b_c = (h(1) + g(1)) > 0$ derives that Inequation (8) holds for all $q \geq 0$; $\frac{b_c}{a_c + b_c} \geq \gamma$:

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

Collecting the two reverse cases finishes the proof of Proposition 3.