The Secrecy Gambit:
Clandestine Power Shifts and Preventive Conflict

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Abstract

Under what conditions should rising states reveal or conceal their military capabilities? We present a model in which announcements of military technology reveal information not only about a country's current capabilities but also its potential development trajectory. The results suggest several popular conclusions about military behavior require amendment. First, we resolve theoretical and empirical disagreement about preventive war by demonstrating such wars can take two separate forms that arise via distinct causal mechanisms: *discovery* and *suspicion*. Second, whereas a robust literature emphasizes states' eagerness to acquire and signal military strength, we identify conditions in which countries attempt to conceal their capabilities or even constrain their own capacity for military growth. Third, we find that the possibility of covert arming compels all states to take costly actions to reassure their adversaries. While this *reassurance tax* is part of the 'gambit' played by ambitious states, it imposes a burden on those that cannot pursue clandestine development. Throughout the paper we illustrate how the theory generates novel predictions for empirical settings that range from clandestine alliances to covert military arming and even counterinsurgency.

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"Secrecy is the first essential in affairs of state."
—Cardinal Richelieu (1641)

1 Introduction

Credible signals are considered the catalysts of military and diplomatic politics. During conflicts, crises, and negotiations, strong countries make costly moves to demonstrate their capabilities and announce their intentions, hoping that these actions will motivate observers to either cooperate or concede. Rich literatures describe the various mechanisms by which convincing signals of military strength can catapult states to greater success in conflict and facilitate more favorable settlements in peace.[1] With research attention focused predominantly on overt signaling, however, a broad class of alternative military and political behaviors remain under-explained. In short, actors often *avoid* signaling their capabilities, opting instead to conceal their assets and obscure their strengths. Militaries, for instance, often strive to keep new weapons systems covert even after they become operational.[2] Allied countries likewise forge and maintain clandestine defense agreements—behavior that contrasts sharply with longstanding theories in which announcements of cooperation pay dividends at the bargaining table.[3] Even individuals engage in secretive military behavior: rather than signal their support for rebel or government forces during civil conflicts, local non-combatants strive to conceal their illicit collaboration with either side.

This paper introduces an explanation for why actors often conceal military technologies—such as arms, alliances, or collaboration—even though public announcements could bolster their bargaining power. In contrast to traditional arming models, we argue military demonstrations convey information not only about a country's *existing* power but also its future development *trajectory*.[4]

[1] Schelling 1960, Banks 1990, Morrow 1989, Fearon 1994, Fearon 1997, Slantchev 2011, etc.

[2] The American F-117 Night Hawk, for example, was revealed only years after it achieved operating capability, once its production run was nearing completion.

[3] Roughly 20% of alliances that existed between 1815 and 1956 were forged in secret and were concealed from non-members until after expiration (Leeds et al. 2002). Powerful states also clandestinely support military proxies and sub-state allies (see Alpher 2015 and Carson 2018). On signaling alliances, see Smith 1995 and Morrow 2000.

[4] Many traditional arming models are tailored to the case of nuclear weapons. Unlike most military developments, which confer benefits incrementally (e.g., iterative improvements in missile technology), nuclear weapons bolster a country's military power almost exclusively when development crosses a final threshold and give states little reason to reveal development progress at intermediate stages. See, for example, Kydd 2000, Baliga and Sjöström 2008, Debs and Monteiro 2014 and Bas and Coe 2016.

By acknowledging this dualism, our explanation captures strategic incentives embedded within a broad range of arming and signaling processes.[5] In particular, countries confront an important dilemma. On the one hand, states may hope to deter rivals with signals of strength or resolve: credible military demonstrations can help countries dispel their adversaries' conflicting beliefs, identify feasible bargains, and avoid costly wars.[7] On the other hand, military demonstrations can motivate opponents to launch preventive attacks: an adversary who discovers its opponent is rapidly gaining power may doubt the rising country's commitment to the status quo and initiate preventive attacks on the basis of this concern.[8] States aiming to maximize their fortune and minimize the risk of war must therefore tread a fine line. To deter hostile rivals they must develop and display military assets that attest to their strengths and capabilities, while at the same time avoiding demonstrations that would lead opponents to infer that the balance of power is shifting too rapidly.

By analyzing how states manage their opposing incentives to hide or announce new military assets, this paper draws attention to several under-appreciated aspects of crisis behavior and generates new predictions for empirical research. First, we contribute to research on military signaling and secrecy by identifying conditions in which states will either advertise or, alternatively, attempt to conceal their military capabilities.[9] We demonstrate that this decision is a key component of a country's strategic arsenal. Under appropriate conditions, states can obtain bargaining advantages by revealing that they possess new arms and technologies, while in other circumstances countries will deliberately cultivate uncertainty and attempt to keep existing military assets covert. Moreover, we highlight conditions in which states will deliberately forgo viable development pathways out of fear that even clandestine arming could trigger war due to premature discovery or exposure.

[5] Consider, for example, Chinese demonstrations of anti-ship missiles, which foment unease among American officials not only by revealing information about China's existing capabilities but also because they suggest a rapid Chinese development trajectory.[6] Similarly, North Korea's Hwasong-14 missile tests in July 2017 indicated not only that the regime could launch low-payload devices against targets in Alaska or Hawaii, but also that missile development was progressing with sufficient speed that parts of the continental U.S. might soon become vulnerable as well.

[7] Schelling 1960, Blainey 1988, Morrow 1989, Banks 1990, Fearon 1995, Powell 1999, Slantchev 2005, Slantchev and Tarar 2011, Fey and Ramsay 2011.

[8] Gilpin 1981, Levy 1987, Fearon 1995, Fearon 1996, Powell 1996, Copeland 2000, Powell 2006, Trachtenberg 2007, Levy 2008, Debs and Monteiro 2014, Bell and Johnson 2015, Bas and Coe 2016, Krainin 2017, Tingley 2017.

[9] Slantchev 2010, Yarhi-Milo 2013, Debs and Monteiro 2014, Lindsey 2015, Bas and Coe 2016, Bas and Schub 2016,Carson 2016, Carson and Yarhi-Milo 2017.

Second, we identify two distinct forms of preventive conflict that can arise from secrecy. The first of these, which we term *wars of suspicion,* can occur when countries strongly suspect their opponents are poised for rapid military development. If the price of reassuring a suspicious state exceeds the potentially-rising country's willingness to pay, no credible concession will enable the two sides to avoid war. In contrast, when an opponent's level of suspicion falls below this threshold, reassurance is possible and peace is sustainable in the short-term. In these circumstances, however, rising countries may gamble by attempting clandestine development, leading to *wars of discovery* when such arming is exposed prior to completion. By distinguishing these two processes, we offer a valuable clarifying point for preventive war theorists: in contrast to widely-cited research, "large and rapid power shifts" are neither necessary nor sufficient conditions for preventive conflict.[10] Moreover, the separation of the two mechanisms allows us to resolve longstanding theoretical and empirical disagreement about the commonality of preventive conflicts. Whereas bargaining theorists primarily depict *wars of discovery* in their models, empiricists have predominantly sought evidence of *wars of suspicion*.

Finally, we demonstrate that the specter of covert military development imposes an externality on non-developers. In short, when countries cannot discern whether their opponents are poised to rapidly militarize, they must regard all adversaries with suspicion—including opponents that genuinely lack the interest or ability to pursue such arming. Just as law-abiding citizens must sometimes make costly behavioral adjustments to avoid or reduce criminal profiling by suspicious authorities, non-developing countries must offer bargaining concessions to assuage the suspicion of their military rivals. This *reassurance tax* constitutes a substantial cost that states could avoid if their capacities for clandestine activity were credibly diminished or if they inhabited a world in which secret arming was impossible. In the discussion section, we detail the implications of this dynamic for research on actors under suspicion of illicit military activity, with empirical applications ranging from weapons proliferation to civilian collaboration with local militants.

[10] Preventive attacks are possible even in the absence of power shifts if opponents are sufficiently suspicious that substantial shifts will occur. Likewise, even ongoing power shifts will not provoke war as long as they remain undiscovered. Our results contrasts with Powell 1999, Powell 2004, Powell 2006.

2 The Secret Development Model

To analyze how countries decide whether to announce or conceal military power, we present a two-period game in which two risk-neutral players, R (the rising actor) and S (the suspicious actor), contest a continuously divisible good represented by the interval [0,1].[11]

At the beginning of the game, Nature determines whether R is "Normal" or "Powerful." R's type determines her probability of victory in a war against S. Following convention, we model war as a costly lottery that determines which player will obtain sole control of the contested good. If war occurs, both players suffer a cost for participating, $C_i \in (0, 1]$, with $i \in \{R, S\}$, and the loser of the contest leaves empty-handed. If R is a normal type, she expects to prevail against S with probability p, but when R is powerful she enjoys a larger probability of victory: $p + \pi$. R's type is private information. Although S knows R is powerful with probability σ, S remains unaware of R's actual type in this stage unless R chooses to "announce" her power.[12] By allowing S to confront uncertainty about R's type, we depict a world in which an adversary may possess clandestine technology, covert equipment, or latent partnerships that raise its overall capabilities beyond what opponents can estimate from observables alone.

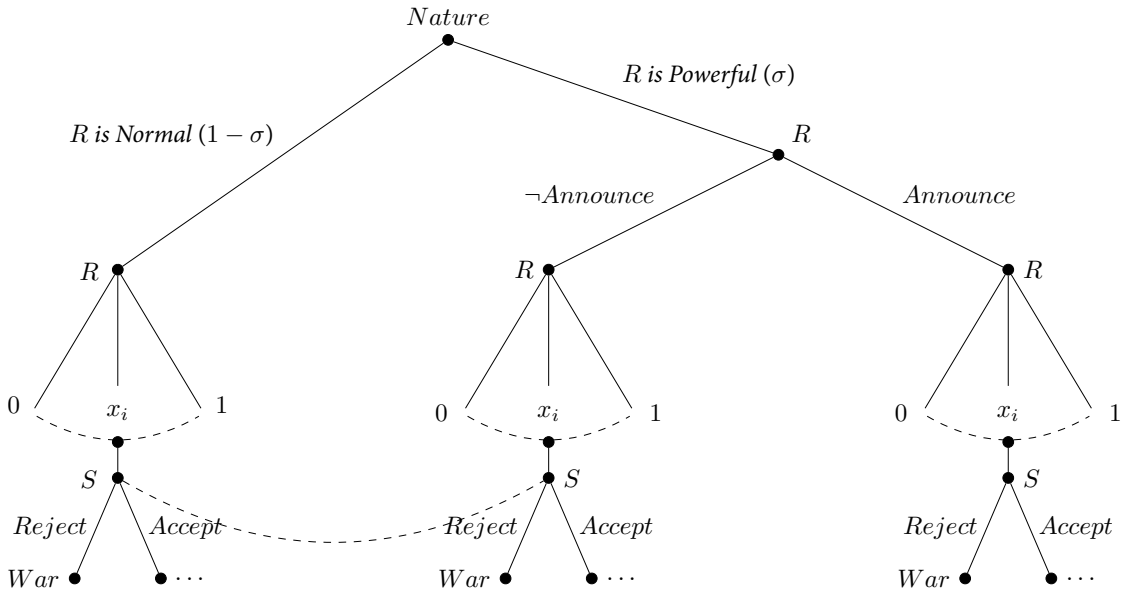
After R learns her type and chooses whether to announce it, the players engage in ultimatum bargaining.[13] R proposes a division of the contested good, which we denote $x_i \in [0, 1]$. S can reject this proposal by initiating an all-or-nothing war as explained above. If war occurs, the game ends. Alternatively, S can accept the proposal, in which case R receives the value she demanded, (x_i), S obtains the complement, $(1 - x_i)$, and play proceeds to a second period. We list the overall payoffs associated with each outcome in Appendix C.[14]

[11] Throughout the paper we refer to R using feminine pronouns and to S using masculine pronouns.

[12] We deliberately allow R's announcement to be both credible and costless because this establishes the most difficult condition for secrecy. If signaling strength was costly or imperfectly credible, it would be easier for us to identify equilibria in which actors pursue secrecy. Our goal is instead to identify conditions in which rational players may avoid revealing strength *even when doing so would be free and perfectly informative.* For similar reasons, the current model does not allow weak types to "bluff" by making false signals of strength.

[13] Fearon 1995, Powell 1999, etc.

[14] Following convention, we discount players' second-period payoffs by $\delta \in [0, 1]$.



Appendix B provides a combined depiction of both model stages.
Appendix C lists the payoffs associated with each outcome.

Figure 1: Secret Development Model, Period 1: Announcement or Concealment

In the second period, R's type determines the range of military development strategies available to her. By "development" we refer to a process that could significantly augment R's military power upon completion: the construction of vehicles and weaponry, the expansion of armed forces, the formalization of a military alliance, or the pursuit of weapons of mass destruction. In all such cases, a country's type—i.e., normal or powerful—influences the level of development it can access in the short term. For example, a powerful country with greater industrial equipment and scientific knowledge can produce a larger number of more advanced vehicles, aircraft, and munitions compared to a country that begins with either fewer factories or less research and development experience. Similarly, a state equipped with a large population as well as powerful economic and logistical infrastructure can rapidly recruit, train, and deploy a larger number of military personnel than an opponent that lacks these initial capabilities. Alliances may also be forged more easily by states that already enjoy strong relations with potential partners as compared to other states that have alienated themselves from their neighbors. Finally, although modeling the development of nuclear weapons is not our explicit goal, a similar logic may also apply *after* a state's initial nuclearization. States that have developed rudimentary or low-yield nuclear arms are, for example, better poised to acquire

thermonuclear weapons in rapid succession or to increase the size of their stockpile compared to states that remain early in the process of nuclear weapons development.

We depict these underlying capabilities by restricting a normal-type R to *normal development*—the marginal level of arming a non-powerful country can accomplish within a single time period. By comparison, if R is powerful she can also choose to attempt *high development,* which represents an investment in arming that, once complete, would boost her military capabilities beyond that which a normal type could accomplish within the same timeframe. Both arming paths result in improvements in R's probability of victory in war against S. If R completes the process of normal development, her probability of victory increases by D, whereas if she successfully completes high development her probability of victory increases instead by Δ. Because high development entails a larger improvement in capabilities than normal development, we assume that $\Delta > D \geq 0$, while the maximum probability of victory remains capped at $p + \pi + \Delta \leq 1$.

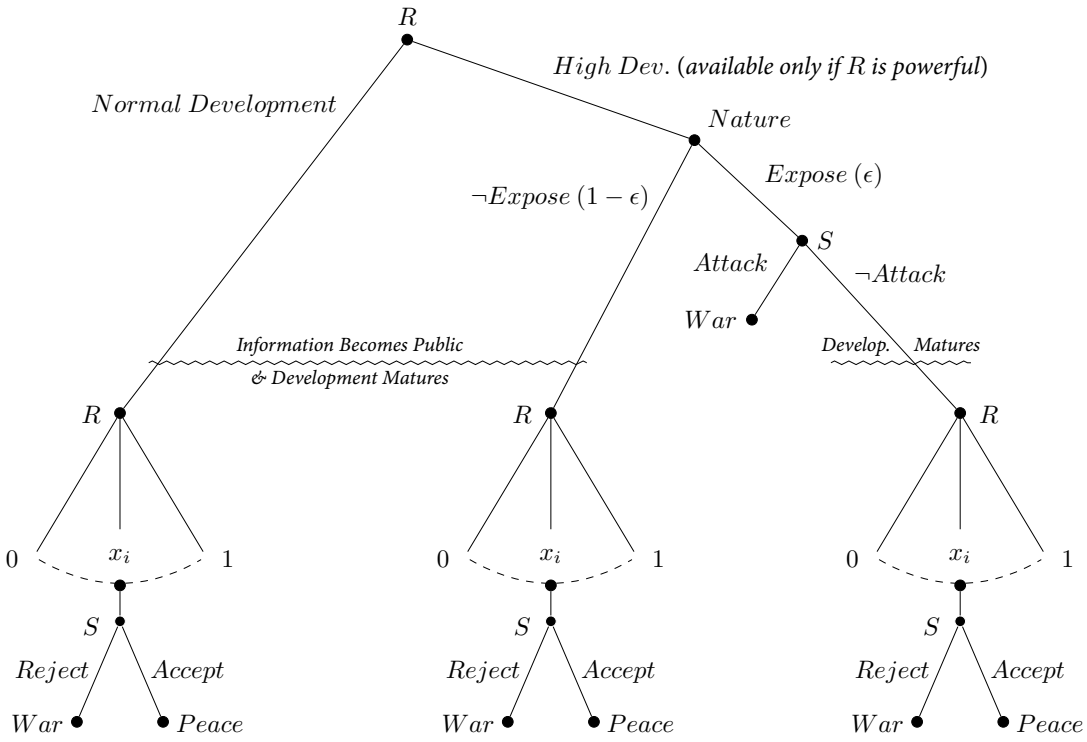
Although potentially fruitful, high development is also costlier and riskier than normal development. We depict these characteristics in two ways. First, if R pursues high development she must pay a cost, $K \in [0, 1]$.[15] In addition, we allow the process of high development to begin clandestinely, but assume that R's effort may be *exposed* with probability ϵ, the value of which is common knowledge.[16] This risk represents the combined chance that ongoing development could be discovered via espionage, could leak via unauthorized or accidental sharing of clandestine information, or could be prematurely revealed through other means. If exposure occurs, information about R's type and development choice becomes common knowledge. S may respond to exposure by launching preventive attacks against R before the "high development" process concludes and while the probability of victory therefore still depends purely on R's type.[17] Alternatively, S may respond to R's exposure by eschewing war and allowing R to continue her development process.[18]

[15] For simplicity, we set the cost of normal development to zero for all types of R, but our results are substantively consistent if we instead assume that normal development also costs K_N, with $0 < K_N < K$.

[16] Results are consistent if R can instead pursue high development publicly after revealing power in the first period.

[17] We can alternatively assume that the development process is partially complete, so R obtains an improvement in his probability of victory that ranges in size between $[0, \Delta)$ depending on the degree of development R achieves prior to exposure. This change does not eliminate the equilibria we identify in the following section.

[18] In the version of the model we present here, S can only interrupt ongoing development by initiating conflict if ex-



Appendix B provides a combined depiction of both model stages.
Appendix C lists the payoffs associated with each outcome.

Figure 2: Secret Development Model, Period 2: Development and Potential Exposure

If R either pursues normal development or, alternatively, pursues high development while avoiding exposure or war with S, the two players once again engage in ultimatum bargaining. As before, R makes an offer x_i that S may either reject or accept, resulting in either war or peace. However, two events occur before bargaining occurs. First, the process development that R initiated at the beginning of this time period reaches maturity, so that R's probability of victory in war is now raised by either D or Δ depending on the form of development she pursued. Second, all information about R's type becomes common knowledge, so that R's true probability of victory is known to both players. This reflects the fact that countries routinely engage in successful military demonstrations in order to depict their capabilities once the development process is complete. Although countries sometimes face difficulty signaling their abilities, we omit this analysis from this

posure occurs. We choose to model the interaction in this way because the structure better reflects the empirical decision-making process of a suspicious actor. In the opening period of our game, S is uncertain whether his adversary is powerful. To ward against the possibility of a *fait accompli* in the future, he initiates preventive conflict in the first period against adversaries who are unable to reassure him with sufficiently generous bargaining offers. Once this screening process is complete, S allows his adversaries to proceed unless the new exposure of information about an ongoing development process forces him to reconsider preventive action.

model for the sake of conceptual clarity and to remain consistent with our depiction of first-period signaling as perfectly credible and costless.[19]

2.1 Model Analysis

We show that Perfect Bayes Equilibria (henceforth, equilibria or PBE) exist yielding five distinct behaviors: (1) *demonstrations of power,* in which the rising player (R) announces her power and derives a bargaining benefit in the first period; (2) *wars of discovery,* in which the suspicious player (S) initiates a preventive attack after becoming aware of ongoing development by R; (3) *fait accompli,* in which R conceals her power and completes high development without exposure, thereby gaining a second-period bargaining advantage; (4) *wars of suspicion,* in which S launches a preventive attack because he suspects that R is pursuing a fait accompli; and, (5) *strategic restraint,* in which R eschews high development to reduce the risk of conflict. We omit discussion of equilibria that rely on mixed-strategies in favor of those in which both R and S adopt pure strategies.

Fait Accompli, Wars of Discovery, and the Risk of Exposure

We begin by considering the players' behaviors in the second period. First, notice that because all information about relative power becomes public prior to the last round of bargaining, the game will always end peacefully if play proceeds to that step.[20] The fact that the outcome will be peaceful, however, does not imply that R's development is irrelevant. Rather, the level of R's development determines the size of the division she can extract during negotiations. R can successfully demand a larger share after completing high development as opposed to low development. The act of completing high military development and then using the associated improvements in power to gain bargaining leverage over an adversary constitutes a *fait accompli.*

[19] An alternative setup in which R must pay a modest cost to demonstrate its power before the final bargaining stage would not eliminate the equilibria we identify in the following section.

[20] Because player S incurs a cost for fighting, he can only credibly reject proposals when the portion of the contested good he would obtain by accepting, $1 - x_i$, is smaller than his war payoff. Player R's cost of war is likewise non-zero, and because both players agree about the expected outcome of war, she strictly prefers to make an offer that S will accept rather than reject. As a result, R will always demand x_i such that S's acceptance payoff $\geq$ his war payoff, and S will accept. For further discussion of why players will achieve agreement rather than costly rejection when engaging in ultimatum bargaining in the final period of a complete information game, see Fearon 1995.

The rewards of a successful *fait accompli* are offset by the fact that war will occur if high development is exposed prior to completion. To observe this, notice that if exposure occurs player S has two options. First, he can attack, which yields an expected payoff of $1 - p - \pi - C_S$. Alternatively, S can refrain from attacking. Because the latter case would force S to negotiate with R after she completes her development, S would obtain a payoff of only $1-p-\pi-C_S-\Delta$. He therefore prefers to attack whenever R's attempt at high development is exposed. We refer to preventive attacks that result from the premature exposure of ongoing development as *wars of discovery.*[21]

We now identify conditions in which R will risk a war of discovery in hopes of accomplishing a fait accompli. R's continuation payoff from choosing normal development when powerful is $p + \pi + D + C_S$. In contrast, R's expected continuation payoff from high development depends on her probability of exposure and reduces to $p + \pi + \Delta + C_S - K - \epsilon(C_R + C_S + \Delta)$.[22] R will therefore pursue high development when the risk of exposure is sufficiently low, or, more precisely, when $\epsilon < \dfrac{\Delta - K - D}{\Delta + C_R + C_S}$. We refer to this condition as the *Low Development Threshold (LDT).* When the inequality is reversed and ϵ exceeds the LDT, the risk of exposure is high enough that even a powerful-type R would instead pursue *strategic restraint* by choosing normal development in the second period. Notice that high development is more likely when the costs of war (C_R and C_S), the cost of high development (K), and the benefits of normal development (D) are each small.

Announcement, Reassurance, and Wars of Suspicion

The previous section describes how the risk of premature exposure (ϵ) influences whether R would attempt or avoid high development in the second period. Player S, however, can take action in the first period to prevent the game from reaching this stage. In particular, if S suspects that R is powerful and is poised to pursue high development, S may initiate a preventive war by rejecting R's proposals during the first round of bargaining. Although risky, such a war would end the game and deny R the opportunity for further growth, thereby ensuring a fait accompli does not occur.

[21] This matches the result in Debs and Monteiro (2014) that preventive wars occur when adversaries are certain of imminent power shifts.

[22] We calculate R's payoffs by comparing ϵ(preventive war) + $(1-\epsilon)$(peace after a second round of bargaining), which is equivalent to $\epsilon(p + \pi - C_R - K) + (1 - \epsilon)(p + \pi + \Delta + C_S - K)$.

Under what conditions would S take preventive military action in the first period? When could R reassure or compensate S in order to dissuade him from such attacks? We answer these questions by identifying the minimum bargaining share $(1 - x_i)$ that S would accept rather than reject. We can characterize S's acceptance threshold by considering two parameters that usefully divide the parameter space into relevant regions. To begin, because ϵ is common knowledge S knows whether the LDT has been crossed and can anticipate whether R would attempt high development in the second period if given the opportunity. S, however, may not know R's type unless R has chosen to reveal it. We therefore let $\hat{\sigma} \in [0, 1]$ depict S's belief that R is powerful at each decision node.

First consider the region of the parameter space in which $\epsilon > LDT$ and the risk of exposure is sufficiently high that R will always pursue low development. Moreover, as we explain below, R will always announce when she is powerful and—regardless of whether she is powerful or normal—will propose a division that induces S to forgo preventive violence. To understand the logic, we can compare S's rejection thresholds in the first bargaining period depending on whether he observes an announcement of power from R. When S is uncertain whether R is powerful, he will reject any bargaining proposals in which $x_i > p + \hat{\sigma}(\pi) + C_S - \delta(D + C_S)$.[23] Because the size of the division R can extract (x_i) increases with $\hat{\sigma}$, R can maximize her bargaining leverage with a *Demonstration of Power* that removes S's uncertainty and causes $\hat{\sigma}$ to assume a value of 1. After making this announcement, R will propose the largest division (x_i) that S would accept. This move induces S to avoid preventive war and enables R to obtain a larger payoff than she could expect to achieve through fighting.[24] Because a powerful R will always announce her type if $\epsilon > LDT$, when player S fails to observe such an announcement he will instead conclude that R is normal and will raise his bargaining expectations accordingly. Nevertheless, even a normal-type R will propose a division that induces acceptance from S.[25] In summary, when the risk of exposure is sufficiently

[23] S anticipates the following payoff from rejecting R's proposal and initiating preventive war: $1 - x_i + \delta(1 - p - \pi - D - C_S)$. In contrast, when S is uncertain of R's type he anticipates a payoff of $1 - x_i + \delta(1 - p - D - C_S) - (\hat{\sigma} \times \delta)(\pi)$ if he accepts R's proposal. S's rejection payoff exceeds his acceptance payoff when the condition in the text holds.

[24] R's payoff from announcing her power and proposing the maximum division (x_i) that S would accept is $p + \pi + C_S + \delta(p + \pi)$. In contrast, R's expected payoff if war occurs at this stage is $p + \pi - C_R + \delta(p + \pi)$. The former value exceeds the latter when $C_R + C_S > 0$, which is always true.

[25] When R is a normal-type, her payoff from proposing the maximum division (x_i) that S would accept is $p + C_S + \delta(p)$,

high, R will forgo high development, will announce her existing power if given the opportunity, and will avoid preventive war by proposing a division that S will accept.

Now consider the region of the parameter space in which $\epsilon > LDT$ and a powerful R would attempt high development. Within this region, announcements of power by R could provoke war by alerting S to the possibility that R will pursue a large power shift in the future. To ward against the possibility of preventive attack, R may opt to conceal her power in the first period—in effect, maintaining temporary secrecy in order to pursue a fait accompli. Regardless of whether she is genuinely powerful, R must also reassure S by offering a relatively generous bargaining division that accounts for S's suspicion that R may secretly be strong ($\hat{\sigma}$). Unfortunately for R, however, S's level of suspicion is sometimes so high that he will reject any proposal that R can credibly offer. In these circumstances, S initiates a *War of Suspicion* in order to remove any possibility of a fait accompli—even though such an option may not in actuality be within R's grasp.

To understand the intuition for these results, we once again begin by comparing S's rejection thresholds depending on whether R announces power. If S is certain R is powerful, he rejects any bargaining proposal in which $x_i > p + \pi + C_S - \delta[C_S + \Delta(1-\epsilon)]$.[26] In contrast, when S is uncertain about R's type, he rejects proposals in which $x_i > p + C_S + \hat{\sigma}(\pi) - \delta(D + C_S) + (\delta \times \hat{\sigma})[D - \Delta(1-\epsilon)]$.[27] Although the perception of status quo power continues to provide R with bargaining benefits, as characterized by the term $\hat{\sigma}(\pi)$ in the preceding inequality, these rewards are offset by the threat that R could achieve a large boost in power in the second period and then force S to yield significant concessions: $(\delta \times \hat{\sigma})[D - \Delta(1-\epsilon) - \pi]$.[28] As a result, R's behavior differs from the low-development region of the parameter space, where R's bargaining leverage increased with $\hat{\sigma}$ and R therefore always prefers to announce her power. In the high-development region, the opposite result holds: R can secure a more favorable first-period agreement from S when she does

whereas R's expected payoff from war is $p - C_R + \delta(p)$. Because $C_S + C_R > 0$, the former always exceeds the latter.

[26] S's expected payoff from fighting if R will pursue high development and he knows R is powerful is $1 - p - \pi - C_S + \delta(1 + \pi - p)$, while his expected payoff from accepting R's offer is $1 - x_i + \delta(1 - p - \pi - \Delta - C_S) + (\epsilon \times \delta \times \Delta)$. S's expected war payoff exceeds his expected peace payoff when the condition in the text holds.

[27] In this case, S's expected payoff from fighting is $1 - p - C_S + \delta(1-p) - \hat{\sigma}[\pi + (\delta \times \pi)]$, whereas his expected payoff from accepting R's offer is $1 - x_i + \delta(1 - p - D - C_S) + (\hat{\sigma} \times \delta)[D - \Delta(1-\epsilon) - \pi]$.

[28] Because $D < \Delta(1-\epsilon)$ when R will pursue high development, $\hat{\sigma}(D - \Delta(1-\epsilon)]$ is negative.

not reveal her strength.[29] If she announced her capacity for future growth, R would be forced to compensate S by requesting a smaller share of the contested good (x_i) than she could claim if S remained uncertain about R's type or if R could commit to normal development. This requirement gives R an incentive to conceal her existing power and to mimic the behavior of a normal type in order to prolong S's uncertainty about R's development trajectory.

Unfortunately for R, there are circumstances in which R cannot propose a sufficiently generous division to reassure S and avoid preventive conflict. In the opening round of bargaining, the minimum amount R can claim is $x_i = 0$, as this would entail forfeiting the entirety of the contested good to player S. Nevertheless, when S is highly suspicious even this amount may not be sufficient to satisfy S.[30] In this case, even the most generous feasible offer from R would still lead to a preventive *War of Suspicion* in which S initiates preventive attacks despite his uncertainty about R's current and future capabilities. In some cases, these wars of suspicion will be waged correctly against secretly-powerful actors who are concealing their abilities, but in other cases they will target normal-type states that are unable to signal their relative weakness.

Even when the players can avoid wars of suspicion, one final aspect of their interaction merits consideration. When S is uncertain about R's type and remains concerned that R may develop significantly in the second period, R must provide reassurance in the form of a smaller initial bargaining offer than she could make if S was not suspicious. When R is powerful and is concealing this power, she expects to recoup these losses after engaging in high development in the second period and, as a result, will always attempt to find a peace deal in the opening stage.[31] When R is normal, however, concessions made in the first round of bargaining are unrecoverable. In effect, when R is normal she suffers a *Reassurance Tax* simply because she inhabits a world in which secret development is possible.[32] By reassurance tax, we refer to the decrease in the size of the first-period

[29] The size of the division R's could claim after announcing power would only exceed the division she could claim while S remained uncertain if $\hat{\sigma} > 1$, which is impossible.

[30] S will require a first-period offer that exceeds the entire contested good when $\hat{\sigma} > \frac{\delta(D+C_S)-p-C_S}{(\pi+\delta[D-\Delta(1-\epsilon)])}$.

[31] When R is powerful, her payoff from inducing acceptance from S exceeds her payoff from war when $\hat{\sigma} > [(\epsilon \times \delta) - 1](C_S + C_R) + \delta(K) - 1$ The right hand side of the inequality is negative, so the condition is always satisfied.

[32] The reassurance tax is positive when $\hat{\sigma} > 0$, which is always true.

division R can peacefully propose when S is uncertain of R's type, compared to what R could otherwise obtain if she could clear away S's suspicion by demonstrating that she was a normal type who would not enact high development in the future.[33]

3 Discussion and Implications

3.1 Power Shifts and Preventive Attack

Several enduring political questions ask how actors respond to shifts in the balance of power. Robust literatures explore whether new alliances deter or provoke conflict,[34] how actors choose between arming or allying in response to threats,[35] and why countries sometimes accommodate emerging rivals but in other cases initiate war.[36] Central to all these discussions is the assumption that power shifts may provoke adversaries to adopt preventive behavior or even engage in preventive attacks.[37] In recent decades, formal theorists have identified specific mechanisms through which such wars can arise. Fearon (1995) introduced an analytic stylization of preventive war as a result of impending shifts in power, Powell (2004, 2006) identified a general condition by which "large and rapid" power shifts should guarantee conflict under complete information, and Krainin (2017) generalized this result to also include slower, long-term shifts.[38] Across all such models, preventive war occurs when one state knows that its enemy is poised to achieve a significant increase in military power in the future. Because this power shift would enable the rising state to extract costly bargaining concessions

[33] In some cases, the cost of reassurance is itself so large that a normal-type R would prefer to fight rather than offer the concessions necessary to induce peaceful agreement from S. More precisely, when she is normal, R's war payoff exceeds her peace payoff when S is uncertain when: $\hat{\sigma} > \frac{C_R+C_S}{\pi-\delta[D-\Delta(1-\epsilon)]}$. In these circumstances, each type of R will propose the maximum division (x_i) that S would accept if S knew R's true type. The difference between the offers made by the powerful and normal types of player R allow S to discern between types, thereby enabling each state to avoid war.

[34] Levy 1981, Huth 1988, Smith 1995, Leeds 2003, Kenwick et al. 2015, Morrow 2017.

[35] Morrow 1993, Glaser et al. 2004, Monteiro and Debs 2014, Yarhi-Milo et al. 2016.

[36] Gilpin 1981, Levy 1987, Powell 1996, Copeland 2000, Powell 2006, Levy 2008, Debs and Monteiro 2014, Bell and Johnson 2015, Bas and Coe 2016.

[37] Thucydides 1954, p. 1.23 famously attributed the cause of the Peloponnesian War to "the growth of Athenian power and the fear which this caused in Sparta." Other prominent discussions of power shifts and war include Gilpin 1981, Levy 1987, Walter 1997, Copeland 2000, Trachtenberg 2007, and Bell and Johnson 2015.

[38] See also Powell 1999, Leventoğlu and Slantchev 2007, and Schub 2017.

from its opponents, countries on the cusp of decline initiate risky preventive action to stop the shift from taking place.

In contrast to Powell, our model demonstrates that "large and rapid power shifts" are neither a necessary nor sufficient cause of preventive war. Preventive attacks can occur even in the absence of genuine arming as long as an opponent *suspects* that military development will occur in the future. Furthermore, even the presence of a genuine power shift may not cause war if an opponent is unaware or uncertain that the shift will occur.[39] These results produce important implications for studies of military arming, power shifts, and preventive conflict. Researchers should not assume that large swings in the balance of power will consistently predict preventive conflict, both because potential power shifts may not be apparent to adversaries until they are publicly revealed and also because suspicious adversaries may launch preventive attacks even when the distribution of power will remain fixed. Instead, empirical research on preventive attacks should account for adversaries' beliefs about the likelihood of shifts in the balance of power.

3.2 The Risks of Signaling

International crises can end in two ways: the first is when one actor loses the capacity to resist—as when its military forces are exhausted through battle—and the second is when at least one actor agrees to concede the disputed stakes. The player that grants such a concession must believe the terms of a potential peace deal are preferable to the payoff she would receive if she allowed the crisis to continue or escalate. Conventional wisdom therefore suggests that strong countries have incentives to signal their military strength and resolve. Credible and convincing signals should persuade opponents that the strong country is unwilling to grant large concessions, so the onus for compromise rests with the weaker actor, which should expect to perform poorly if negotiations fail and war begins.[40]

This model demonstrates that countries also face incentives to forgo signaling—and to eschew

[39] See Debs and Monteiro 2014 and Bas and Coe 2016 for similar results.

[40] Banks (1990), Fearon (1995), etc.

development—in appropriate circumstances. Although states should eagerly announce their military development when they can do so without provoking conflict, signaling strength may *not* be useful when the opposite is true. These findings contribute to our understanding of the risks and benefits of signaling. Whereas previous work recognizes the risks of signaling when war is already imminent—Slantchev (2010), for example, observes that signaling can enable opponents to prepare better for war, while Lindsey (2015) shows that signals may allow adversaries to respond with better tactics *during* war—our model demonstrates that sharing information can directly provoke war where none would otherwise occur.

Finally, because our model identifies conditions in which secrecy is preferable as well as those in which announcements can be made safely, our results may help explain variation in the effort states direct toward concealing nuclear weapons development. Previous work identifies nuclear development as the optimal circumstance in which states should prioritize secrecy rather than alert their adversaries to the imminent completion of a weapons system.[41] Nevertheless, even potential proliferators have exerted varying levels of effort toward such secrecy. Consider the case of North Korea, which made little effort to conceal its interest in nuclear weapons development early 2000s, going so far as to withdraw from the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), insist to American diplomats that it already possessed weapons, and expel several IAEA inspectors. In contrast to many other potential proliferators, Pyongyang already maintained relatively robust *conventional* military capabilities—a factor that limited the size of the power shift that could occur even if the state obtained nuclear weapons. Countries with smaller conventional militaries or for whom nuclear weapons would cause a larger shift in military capability relative to key adversaries may need to devote greater effort to maintaining secrecy.

3.3 Wars of Discovery and Wars of Suspicion

Our model clarifies the logic of preventive war by showing that such wars occur through two distinct mechanisms. *Wars of discovery* can occur when clandestine activities are prematurely exposed.

[41] Debs and Monteiro (2014), Bas and Coe (2016).

Consider the Soviet behaviors that provoked the 1962 Cuban Missile Crisis. Concerned about a potential U.S. invasion of Cuba, Soviet Premier Nikita Khrushchev decided to deploy weapons on the island in hopes that such weapons would equalize "what the West likes to call the 'balance of power.'"[42] To avoid provoking American preventive actions, the Soviets sought to keep the extent of their military relationship with Cuba a secret the power shift was complete.[43] Indeed, when Cuban leaders proposed that the two countries announce their partnership in order to establish immediate deterrent benefits, Khrushchev refused the request, promising instead to reveal the full extent of Soviet-Cuban military cooperation in a fait accompli once all deployments were operational..[44] The Soviets' secrecy gambit backfired on October 14, when American U-2 reconnaissance identified offensive missile sites in San Cristobal. Although Khrushchev eventually chose to withdraw the missiles, their discovery nearly provoked a war of discovery with the United States.[45]

On the other hand, *wars of suspicion* arise when threatened states suspect their adversaries are or will conceal significant development activity—regardless of whether such activity actually exists. One prominent example of such suspicion relates to the United States' invasion of Iraq in 2003. Substantial debate exists in the literature as to why the United States concluded that Iraq possessed WMD and, more importantly, why Iraq was unable to quell American suspicions.[46] Although other researchers blame the United States for its failure to gather accurate intelligence about Iraqi WMD development,[47] their explanation raises the question of why Iraq was unable to "clear the air." As President George W. Bush lamented in his memoirs, "If Saddam [Hussein] didn't have WMD, why

[42] Quoted in George and Smoke (1974, p. 462). President Kennedy's statements reflect a similar sentiment, including his lament that "The Soviet move had been undertaken so swiftly, so secretly, and with so much deliberate deception... that it represented a provocative change in the delicate status quo" (Quoted in Lebow 2000, p. 15).

[43] Several Soviet personnel argued that exposure could provoke war (see Lebow and Stein 1995 and Lebow 2000).

[44] Hansen 2002.

[45] Our model abstracts from analyzing how the leaders ultimately averted war in this case. It is possible that when Khrushchev initially opted to attempt secret development he underestimated the costs associated with a war of exposure. When Soviet missile deployment began, President Kennedy had not yet publicly pledged to prevent Cuba from obtaining offensive military capabilities. As a result, Khrushchev might have assumed that exposure could result in American preventive action that ell short of nuclear conflict. As the crisis elapsed, a series of unauthorized incidents coupled with Kennedy's behavior led Khrushchev to believe that widespread nuclear engagement was more likely.

[46] For recent examples, see Duelfer and Dyson (2011), Lake (2010), McKoy and Lake (2011), Lake (2013), Debs and Monteiro (2014).

[47] See Kaufmann (2004), Flibbert (2006), Lake (2010), and Debs and Monteiro (2014) for arguments that the U.S. failed to optimally gather and process information.

wouldn't he just prove it to the inspectors?"[48] Our model provides a formal explanation for both Hussein's failure to provide information and the United States' choice to invade: the strategic environment inhibited Iraq from sharing information that would have reassured the U.S.[49]

In the language of our model, American suspicion ($\hat{\sigma}$) that Iraq was developing WMD was extremely high in the prelude to the invasion. The United States developed a perception throughout the 1990s that "Iraq would never be forthcoming, and that if it was blocking access to the UN [inspectors], then it must have something to hide."[50] In effect, even though Iraq was not developing WMD, the state was subject to a *reassurance tax* because it inhabited a security environment in which clandestine activity was possible. To complicate matters further, Hussein, was initially unwilling to offer convincing evidence that he had dismantled his nuclear program for fear that doing so would also alert his domestic and regional opponents to his military weakness.[51] Even when Hussein's priorities shifted and he allowed United Nations (UN) inspectors to return in November 2002, the United States remained suspicious that Iraq was concealing additional capabilities and was on a trajectory to obtain WMD. In short, the largest credible concession that Hussein could make in terms of inspections still could not reassure the United States. In the end, the Bush administration remained suspicious of Iraqi development and the U.S. embarked upon a war of suspicion.

By identifying this distinction between wars of discovery and wars of suspicion, we make three contributions. First, we bring formal models of preventive war into better harmony with historical

[48] Bush 2010, p. 269. Note that although there is still much debate about whether members of the Bush administration maintained additional interest in the conflict, the overriding question is why Iraq did not demonstrate that the United States' publicly-stated rationale for war was built on flawed estimations of Iraqi WMD production.

[49] This corresponds to Lake's (2010) conclusion that Hussein chose not to reveal his lack of WMD because by doing so he would have incurred steep domestic costs and been constrained from deterring other opponents.

[50] Duelfer and Dyson 2011, p. 97. Following the terrorist attacks of September 11, 2001, members of the U.S. intelligence community also became acutely aware that they lacked the capabilities to detect all potential security threats in a timely manner (Debs and Monteiro 2014). As a result, the Bush administration adopted its "one percent" doctrine, according to which it treated even a one percent chance that Iraq could develop nuclear weapons as an unacceptable risk (Lake 2010).

[51] As Gordon and Trainor (2006, p. 63) explain, Hussein's "top priority was protecting his government against potential coups and internal threats... Iran, an adversary with whom he had fought a bloody eight-year war, was next on the list of dangers." The Iraqi leader appears to have believed that maintaining ambiguity over his WMD arsenal would simultaneously quell domestic unrest and deter attacks from Tehran. Duelfer (2004, p. 32) likewise argues that "This led to a difficult balancing act between the need to disarm to achieve sanctions relief while at the same time retaining a strategic deterrent. The Regime never resolved the contradiction inherent in this approach."

and qualitative accounts of conflict. Whereas canonical formalizations depict wars of discovery in which actors become aware of ongoing or imminent power shifts, historians often describe wars of suspicion in which states remain uncertain but suspicious of their rivals' developments. Our model not only draws attention to both causal logics but also identifies conditions in which each category of preventive war is likely to occur.

Second, distinguishing between these separate mechanisms allows us to clarify the means by which states may attempt to avoid preventive war. Countries can eliminate the risk of wars of discovery by forgoing development—after all, development cannot be exposed if no development has occurred. However, countries cannot always eliminate the threat of wars of suspicion: when player S's suspicion level exceeds $\frac{\delta(D+C_S)-p-C_S}{(\pi+\delta[D-\Delta(1-\epsilon)])}$, player R will lack any credible means of demonstrating that she has eschewed secret development and war is unavoidable.

Finally, acknowledging the difference between discovery and suspicion improves our understanding of how uncertainty relates to preventive conflict, an issue that is much debated in recent work. Whereas Debs and Monteiro (2014, p. 2) claim that "when power shifts are endogenous... preventive war requires uncertainty," their view contrasts with Krainin (2017, p. 106), who argues that "incomplete information is not necessary to cause war using the logic of commitment problems." Our model shows that uncertainty yields different effects across each category of preventive conflict. Wars of suspicion are indeed caused by uncertainty: adversaries could avoid conflict if only R could credibly prove that it was not developing. However, wars of discovery are not caused by uncertainty but rather by the removal thereof: if player S remained uncertain about R's ongoing development, no discovery would occur and S would refrain from fighting.

3.4 Empirical Generality and the Reassurance Tax

Throughout this paper we refer to "war," "countries," and "military development" in order to facilitate intuition. However, the mechanisms we identify should apply to interactions beyond full-scale interstate wars. For example, although we discuss "preventive war," the action could describe any activity—violent or otherwise—in which risky or costly actions by one actor can thwart the relative

gains of another. A country that discovers an adversary's secret research lab could, for example, attempt to destroy the lab or its employees with airstrikes, covert sabotage, cyberattacks, etc. None of these actions constitute "war" in popular parlance, but all fit the mould of our model by depicting costly and risky actions that can prevent the rise of an adversary.

Likewise, the players in our model could include any strategic actors that are locked in bilateral conflict, ranging from states and insurgents to businesses and labor unions. Consider businesses deciding whether to patent the technologies they develop. A firm that submits a patent can lock in a small flow of benefits in the form of licensing fees that competitors must pay if they adopt equivalent technology. However, patents also sometimes expose development pathways by making technical solutions public to interested competitors. In some cases, the information contained within a patent filing can allow competing firms to catch up in the research and development race in ways that counteract the revenue gained via licensing. As a result, businesses sometimes choose to delay or even forgo patent filings to avoid giving the competition an opportunity to react.[52] Similarly, when a labor union discovers pro-business lobbies are secretly advancing anti-union legislation, the union may take preventive action by carrying out strikes or counter-lobbying to quash the bill. Although such forms of competition are not war in the colloquial sense, and "legislation" is not the same as "military development," the situation parallels the strategic calculus laid bare by our model.

The wide applicability of our model is particularly helpful for making intuitive sense of one of our key discoveries, the *reassurance tax*. The option of secrecy, as noted earlier, is a boon to actors wishing to pursue ambitious power shifts, but a burden to those happy with the status quo. To see this latter point, imagine a citizen living in a surveillance state, where citizens' actions are constantly monitored for signs of radicalization or criminality. Under such circumstances, citizens must curtail their behavior in various ways in order to avoid drawing suspicion. If the government is for some reason suspicious of a particular religious group, for example, citizens may avoid converting to that religion or associating with its members. Current members may likewise choose to eschew outward

[52] The WD-40 company famously chose not to patent its eponymous product "in order to avoid having to disclose the ingredients publicly" (Martin 2009). Likewise, Elon Musk refuses to patent technologies developed by his company SpaceX, arguing that "Our primary long-term competition is in China. If we published patents, it would be farcical, because the Chinese would just use them as a recipe book" (Anderson 2012.)

signals of devoutness either in public or on social media for fear of being profiled.[53] We think of these self-imposed curtailments as compensation paid by citizens to reassure suspicious authorities.

The same concept also applies to the burgeoning research on civilian wartime informants.[54] In this literature, a government seeks to crush an insurgency embedded in a civilian population, but requires strategic information from the civilians on the whereabouts of insurgent weapons caches or hideouts. Models in this literature have so far treated the interaction as a one-off game: the civilian chooses whether or not to share with the government information about the insurgents, and the game ends thereafter.[55] In reality, of course, intelligence agencies cultivate informants to provide a flow of information over time. As a repeated game, secrecy becomes paramount, because insurgents and government forces may attempt to kill, turn, or detain informants they suspect of collaboration with the adversary.

As our model highlights, because state informants and non-informants live under the same weight of suspicion, both sets of civilians must take costly steps to reassure belligerent groups that they are not collaborating with the opponent. A civilian who seeks to reassure an insurgent might, for example, opt to avoid places frequented by government officials or feel compelled to refuse government services for fear that insurgents would view such transactions as compensation for information. In the most extreme cases, citizens suspected as government supporters may be forced to directly assist insurgents so as to dispel suspicion and reduce the likelihood insurgents will engage in "preventive action." In all cases, reassurance implies a polarizing effect, where civilians who might otherwise have followed a neutral path are instead forced to adopt behaviors that help or hinder each belligerent.

Likewise, external shocks that convince a belligerent group that secret collaboration is more likely to exist—or, alternatively, that collaboration would prove more impactful if left unchecked—will yield two perverse effects. First, as outlined above, shocks of this type will raise the *reassurance*

[53] Consider the actions of crypto-Muslim Moriscos who hid their identify by practicing *taqiyya* during and after the Spanish inquisition (Harvey 2005), the behavior of Jews who claimed false identities in occupied Europe, and the experience of targeted civilians in Vietnam, Colombia, Mosul, and other recent or contemporary conflict settings.

[54] Condra and Shapiro 2012, Shapiro and Weidmann 2015.

[55] Berman et al. 2011.

tax, forcing civilians to engage in costly actions to mollify each belligerent. Second, both government and insurgent forces will grow more willing to attempt *wars of suspicion* against civilian populations whose clandestine support for the enemy could, they fear, swing the course of the conflict. Empirically, these reactions are problematic for difference-in-difference (DiD) studies that aim to estimate the effects of new technologies, such as mobile phones or counterinsurgency hotlines, that are meant to facilitate government informing.[56] Wherever informing occurs and secrecy is plausible, 'reassurance' activity will exist and DiD estimates will conflate these twin effects.

4 Conclusion

This article presents several major claims. First, the ability to announce or conceal military development is an important strategic tool. Whereas previous research suggests that signals of strength enable states to access deterrent and bargaining benefits, we show that such displays can also provoke conflict. As a result, countries have incentives to hide their capabilities even when signaling is credible and costless. Similarly, states should not always pursue the largest long-term improvements in military capability. To minimize the risk of preventive war, countries may rationally avoid forming alliances with strong partners or developing potent military technologies—even if such options are free to implement. Researchers should revisit theoretical and empirical research that assumes increases in military power are either universally desirable or are consistently associated with favorable conflict and bargaining outcomes.

Our second finding is that the *threat* of clandestine development can itself provoke war and create significant distributional consequences. Whereas previous theoretical research on preventive conflict focuses largely on complete-information environments where one actor becomes aware of an imminent power shift by the opposing side, we demonstrate that the mere suspicion of such a shift can compel an enemy to fight. Likewise, all actors under suspicion of development must pay concessions to their opponents in order to achieve peace, even if development has not actually occurred and will not occur in the future. Thus, the possibility that some actors are engaged in secret

[56] See Shapiro and Weidmann (2015) for an example of such a shock.

behavior creates negative externalities for those who do not participate in secret development.

Critics may complain that our stylized description of military arming abstracts too far from the complexity of the international environment. Indeed, we acknowledge that the model does not incorporate several realistic nuances that may yield interesting behaviors. Future researchers may investigate how the strategic behavior may change when opponents can invest resources in either intelligence or, alternatively, counter-arming. Identifying how states balance these options could prove a worthwhile extension. Likewise, our model considers a strategic interaction between only two players, whereas in reality military technologies are fungible and countries often confront several adversaries simultaneously. How countries might behave when arming promises to deter aggression from one opponent but risks inciting aggressive action from another opponent is an important and intriguing question for future research. Finally, our model provides actors with a decision to pursue or avoid a development whose scale is exogenously determined. This reflects the fact that many power shifts are beyond states' ability to select and that the range of available options if often heavily constricted.[57] Nonetheless, future work should investigate how states behave when they can endogenously determine the scale and speed of their developments. Though our model abstracts away from these and many other potential extensions, the cases suggest that it usefully describes a series of important historical episodes and, perhaps more importantly, demonstrates that behavior as seemingly diverse as civilian interactions with counterinsurgents, German and Soviet cooperation in the interwar period, and firms' decisions to file patents are well explained within a consistent theoretical framework.

Finally, the results should inform our thinking about the relationship between information, secrecy, and war. Dominant theories of international conflict suggest that war is most likely when optimism persists because actors are unable to share information. In contrast, our model highlights the possibility that strategic concealment may enable states to maintain peace, whereas wars of discovery may occur when information is revealed prematurely. Thus, whereas Blainey (1988, p. 56) lamented that war must sometimes "provide the stinging ice of reality" that eliminates optimism

[57] See Krainin (2017) and Schub (2017) for examples.

and enables states to settle, we show that an alternative is also true: when states are initially uncertain about the presence of an upcoming power shift, the "stinging ice of reality" can alert them to a potential threat and thereby itself provoke war.

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Appendix A: Secret Alliances and Wars of Suspicion

Although we believe the theoretical results of the paper stand on their own, this online appendix provides empirical support for the existence of *Wars of Suspicion* using historical data on secret military alliances, which serve as a useful test for our argument both theoretically and empirically.

First, military alliances match our theoretical assumptions by capturing the dual signals that military arming can send. Prevailing theories of alliance formation focus largely on the first half of this dualism, emphasizing that alliances enable states to credibly signal their collective power.[58] In short, by forming and announcing a military alliance, two countries reveal their intention to cooperate with each other on matters of policy or defense.[59] Opponents that observe and believe the alliance should react as though the allies have aggregated their capabilities. Even if the aggregation is inefficient, the allied coalition should enjoy greater deterrent capability and bargaining leverage than its individual members could individually claim prior to the announcement.

Despite these deterrent and bargaining benefits, alliance announcements may also alert opponents to the development trajectory of an allied coalition. As we discuss in the paper, the literature on preventive war argues that a threshold exists in military arming whereby declining states may pursue preventive wars when they anticipate sufficiently large and rapid shifts in the balance of power. By announcing an alliance, a state whose individual development trajectory otherwise fell within acceptable bounds might signal that its development may instead occur at a much higher rate, thereby motivating opponents to initiate preventive conflict so as to thwart the imminent power shift. The desire to avoid preventive conflicts may motivate rising states to conceal military alliances until their development has progressed sufficiently that it may be safely revealed.

Consider, for example, the clandestine military cooperation between Germany and the Soviet Union in the European interwar period. Following Germany's defeat in WWI, the victors placed strict limits on the size and scope of the German military, limiting membership in the German military to 100,000 soldiers and explicitly forbidding the country from procuring submarines, aircraft,

[58] Smith 1995; Fearon 1997; Morrow 2000.

[59] Because alliances are costly to initiate and maintain, only states that are committed to the alliance terms and who expect to gain from military cooperation should opt to ally.

or armored vehicles. Germany bypassed these regulations in part by forming a secret agreement with the Soviet Union whereby the Reichswehr dispatched advisors to train young Soviet officers in exchange for access to hidden military bases and manufacturing plants inside Russia. Throughout the 1920s and early 1930s, thousands of German scientists and engineers worked within the Soviet Union testing military prototypes, developing chemical weapons, and laying the groundwork for the mass production of new German weapons and equipment. In the early phases, the two countries sought to conceal their activity out of concern that the western allies would undertake preventive action if the scale of German rearmament became public knowledge. Indeed, when an emissary from Germany was briefly detained while ferrying documents pertaining to the military cooperation, he worried that the great war would "reignite if the allies discovered what I [was] carrying."[60] By 1933, however, these fears had dissipated, and Hitler concluded that his country's development had progressed far enough that he could publicly acknowledge rearmament without provoking the allies into preventive action.

The German-Soviet cooperation is far from the only case in which states concealed their military cooperation. Secret alliances are also a useful test case for our theory because of their long existence as a common feature of international politics. For example, Grosek (2007) identifies 593 secret treaties that existed between 1521 and 2000. Although more limited in temporal coverage than Grosek's qualitative approach, the Alliance Treaty Obligations and Provisions (ATOP) dataset facilitates the systematic study of secret military alliances that have existed since the end of the Napoleonic wars.[61] Based on the ATOP data, at minimum roughly 20 percent of all alliances formed between 1815 and 1956 were secret in nature.[62]

Other researchers have used this data to provide support for alternative theories of conflict escalation. Most prominently, Bas and Schub (2016) argued that the existence of secret alliances could

[60] Johnson 2016.

[61] Leeds et al. 2002.

[62] Bas and Schub (2016). Whether additional clandestine alliances existed and whether secret alliances remain prevalent today is difficult to assess—although such agreements might have declined in frequency, they may also exist while remaining hidden from researchers. See also Ritter 2003.

provide support for the theory that wars sometimes result from mutual optimism.[63] According to their theory, states that participate in secret alliances possess greater military capabilities than their adversaries can anticipate. Opponents that lack accurate information about such alliances will remain "optimistic" insofar as they overestimate their own likelihood of victory or underestimate the likely costs of a potential conflict against a secretly-allied foe. Applying their theory to dyadic interstate data between 1816 and 1923, Bas and Schub (2016) find an association between the presence of secret alliances and the likelihood of Multilateral Interstate Disputes (MIDs).

Because theories of mutual optimism relate to the status quo distribution of power—as opposed to how the distribution of power might shift in the future—Bas and Schub (2016) did not account for the possibility of power shifts in their empirical analysis. In contrast, our theory depicts a scenario that includes *both* information asymmetries about existing power as well as potential commitment problems related to shifts in future power. As a result, we argue that the relationship between secret alliances and conflict may not stem purely from mutual optimism. For example, if war would not occur if both sides were fully informed about one another's capabilities, one wonders why secretly-allied states would not avert inefficient wars by revealing their alliances on the eve of conflict. In other words, if alliance participants genuinely possess hidden military strength as a result of their collaboration, disclosing the alliance should induce an optimistic opponent to return to the bargaining table, thereby allowing both sides to avoid the costs of fighting.

Bas and Schub (2016) provide two possible explanations for this behavior. One focuses on domestic factors. In this view, leaders continue to conceal their alliances when publicly announcing the alliance would force the leader to incur domestic or international political costs. This mechanism requires a questionable reading of history. Many of the alliances in the data were signed by autocratic states during a time period in which citizens lacked significant political influence and were only weakly attuned to international relations—conditions in which leaders should be insulated from the costs of domestic backlash.[64] The authors' second explanation for why states continue to keep their

[63] On mutual optimism, see Morrow 1989; Fearon 1995; Powell 1999; Slantchev 2003; Slantchev and Tarar 2011; Fey and Ramsay 2011; and Lindsey 2019.

[64] Audience-based explanations struggle to explain why states would conceal alliances during negotiations but adhere

alliances secret on the eve of conflict relates to Slantchev (2010)'s "Feigning Weakness." In this case, the allies believe (1) the announce of the alliance may not deter the adversary from initiating conflict, and (2) the announcement would reduce the allies' *tactical advantages* on the battlefield—by, for example, alerting the enemy to the possibility that the war would be fought on multiple fronts.[65] This possibility, however, abstracts away from the theory of mutual optimism by arguing that war would still occur even if the allied side announced its alliance and revealed accurate information about the expected outcome of war.

We resolve these concerns by demonstrating that the empirical relationship between secret alliances and conflict may not result from mutual optimism but rather from *wars of suspicion*.[66] In this view, adversaries initiate wars against countries they suspect may be secretly allied. If opponents' suspicions perform better than random chance—in other words, if they are more likely to pursue *wars of suspicion* against secret allies than against states that are *not* secretly allied, an association between secret alliances and conflict should exist in the data. Moreover, unlike the mutual optimism explanation, our theory regarding *wars of suspicion* provides a justification for why states forge secret alliances in the first place: as in the example of Germany and the Soviet Union, alliance members choose to conceal their cooperation out of concern that revealing the alliance would provoke preventive attacks from adversaries who realize that the allies may experience more rapid military growth than would otherwise be possible.

How can we distinguish empirically between these differing explanations for the association between secret alliances and war? Whereas the mutual optimism account suggests that such al-

to them once conflict begins. If constituents can deter leaders from even *announcing* alliances, how could leaders fulfill the terms of their alliances if called upon to do so? Deploying troops on behalf of an unpopular ally should pose a larger political liability than merely announcing one's support. For accounts of secret cooperation that are not restricted to alliances, see Carson and Yarhi-Milo (2017) and Carnegie and Carson (2018).

[65] See also Lindsey (2015).

[66] The empirical support we offer throughout this section is also consistent with our *wars of discovery* mechanism. In this case, the MIDs we observe in the data might have occurred because opponents discovered evidence of secret alliances forged between rapidly-growing states. Unfortunately, we cannot adjudicate between this possibiliy and our *war of suspicion* mechanism, because we lack the evidence necessary to provide a reliable measure of whether alliances remained perfectly clandestine in the immediate prelude to each MID. Note, however, that the although possibility of premature exposure is consistent with our overall theory, it is problematic for the mutual optimism explanation: alliances should not contribute to private optimism if they become public knowledge prior to a dispute. MIDs that occur in the wake of public announcement or discovery must therefore result from an alternative mechanism.

liances should consistently raise the probability of conflict within all dyads in which they exist, the *war of suspicion* theory is conditional. According to our theory, maintaining alliance secrecy is most important when allies are acquiring military power relative to a rival state. As such, opposing states should be most concerned about the potential existence of secret alliances—and most willing to attempt *wars of suspicion*—when they confront adversaries that are experiencing improvements in military power. In contrast, countries should only rarely launch *wars of suspicion* against secretly-allied adversaries that are not growing in relative power.

Empirical Approach

To test for the existence of a conditional relationship between shifts in military power, secret alliances, and the onset of conflict, we begin by replicating the empirical setup in Bas and Schub (2016). The unit of analysis throughout our tests is the non-direct dyad year, using only politically relevant dyads in which states are contiguous, are separated by less than 400 miles of water, or at least one is a major power. We further restrict our analysis to observations that fall between 1816 and 1923 because, as we discuss above, secret alliances almost entirely disappear from observable data outside of this range.[67]

To assess whether each member of a dyad participated in a secret alliance with a third party, we used data from ATOP, which codes whether any or all alliance provisions are secret. Throughout this section, we code alliances as secret only if all of their provisions are secret. To account for the possibility that rational actors acknowledge the *possibility* that their adversaries may participate in secret alliances, Bas and Schub (2016) develop a measure that incorporates each actor's prior belief about the existence of such alliances. They base this prior on the average rate of secret alliances in the dataset and the share of the world's military capabilities that those alliances possessed. Thus, the variable takes a value of "1" if and when a country within a dyad participates in one or more secret alliances that render the country more powerful than its adversary would anticipate if such

[67] Because secret alliances are unobserved outside of this range, including subsequent observations would violate the positivity assumption that treated and control units exist across strata (see Petersen et al. 2012). The only secret alliance to appear in the ATOP data post 1923 is the 1956 alliance between the United Kingdom, France, and Israel that preceded the Suez Crisis.

alliances were randomly dispersed across countries.[68] In contrast, the measure takes a value of "0" when members of a dyad participate in no secret alliances or, alternatively, are participants in a smaller or weaker set of secret alliances than their adversaries' baseline beliefs would suggest. For the sake of simplicity, we refer to this measure as *Secret Alliances* throughout our analysis.

To account for the conditional relationship between *Secret Alliances* and shifts in the balance of power, we created a second variable, *Power Shift,* which characterizes the change in the two states' relative military capabilities over a recent time period. To measure the states' military capabilities, we used CINC scores (Singer et al. 1972), a composite measure of a state's population totals, industrial output, military personnel, and defense expenditure that, although crude, is widely used in the conflict literature as a proxy for military power during the time period of our data. Our *Power Shift* variable measures the change in the weaker state's share of the two states' combined CINC scores that occurred over the preceding three, five, or ten years. When evaluating our hypothesis, our explanatory variable of interest is the interaction between the *Secret Alliances* variable and the *Power Shift* variable. We predict that *Secret Alliances* should be associated with significantly higher likelihoods of conflict only when they are accompanied by large *Power Shifts*.

Our primary dependent variable is Militarized Interstate Dispute (MID) onset,[69] a binary measure that assumes a value of "1" in observations where one dyad member threatens to use force, initiates a display of force, or actually uses force up to and including war. Limiting the outcome variable to a binary measure in which force is actually used yields similar results.

We include a series of control variables to account for confounding factors that are prominently associated with MID onset in the existing literature. Because previous research suggests that conflict may be more likely to occur between states with similar capabilities,[70] we include a *Relative Capabilities* variable that measures the weaker state's current share of total dyadic capabilities using CINC scores, with .5 representing power parity between the two sides. Geographically proximate

[68] This measure is further offset by the possibility that an adversary is itself party to a secret alliance.

[69] Ghosn et al. 2004, Palmer et al. 2015, Maoz et al. 2019.

[70] Reed 2003.

states engage in conflict at higher rates than distant states,[71] so we include a binary *Contiguity* variable that indicates whether the states in a dyad share a border or are separated by less than 400 miles of water.[72] An extensive literature on the democratic peace suggests that conflict should occur less frequently in dyads where both states are democracies compared to dyads where one or both states are non-democracies.[73] We therefore include a *Joint Democracy* variable that indicates whether the Polity IV scores of both states in a dyad exceed six.[74] States that are themselves allied are less likely to initiate disputes with each other, so we also include an *Allied Dyad* indicator for whether the dyad members share a formal alliance.[75] Finally, we include polynomial measures of the time elapsed since the dyad's most recent MID: *Peace Year, Peace Years*^{2}, and *Peace Years*^{3} so as to account for temporal dependence in the data.[76]

Results and Robustness

We estimate dichotomous outcome models using logistic regression with standard errors clustered by dyad. We find consistent support for our hypothesis across various model specifications. Table 1 presents results using several distinct duration periods for our *Power Shifts* variable. Model 1 measures the change in the weaker state's relative capabilities over the preceding year, while successive models increase the duration of the power shift to a maximum of five years.[77]

Notice first that across all specifications that main effect of *Power Shifts* is either null or negatively associated with the occurrence of a MID at conventional significance levels, in line with our expectation that when states states engage in visible power shifts—such as those related to substantial changes in CINC scores—they should do so at sufficiently conservative levels so as not to

[71] Bennett and Stam III 2004, Starr and Thomas 2005, Tir 2010, Toft 2014. See also Fang and Li 2016.

[72] Because the dataset is restricted to politically-relevant dyads, the only non-contiguous states are major powers in observations where they are not adjacent or proximate to the other member of their dyad.

[73] Gleditsch 1992, Rummel 1995, Gartzke 1998, Oneal et al. 2003.

[74] Marshall and Jaggers 2002

[75] Gibler and Sarkees 2002.

[76] Carter and Signorino 2010.

[77] Although existing literature on preventive wars often focuses on what Powell (1999) referred to as "large and *rapid*" power shifts (emphasis added), other research suggests that states may feel threatened by shifts in power that occur more gradually or over longer time periods. See Krainin (2017) for a recent formalization of one such mechanism.

provoke preventive conflict. Likewise, across all specifications, the main effect of *Secret Alliances* is positively associated with MID occurrence. This result is consistent with Bas and Schub (2016), but is also consistent with our interpretation that opponents are able to target their suspicion against states that they believe are likely candidates for secret alliances.

Most importantly, notice that the existence of *Secret Alliances* within a dyad is associated with a *larger* increase in the probability of a MID when a power shift is also occurring. To facilitate interpretation of the interaction between *Power Shifts* and *Secret Alliances,* Figure 1 plots the predicted probability of a MID at different levels of each constitutive variable. When the weaker state within a dyad has experienced only a small power shift over the preceding five years, the existence of a secret alliance does not significantly increase the probability of an international dispute relative to the alternative case in which secret alliances do not exist. Once again, this is consistent with our prediction: even if an opponent suspects that a *Secret Alliance* may exist, this suspicion is insufficient to motivate the opponent to initiate preventive conflict because power is observably shifting between the two states only gradually. In contrast, on the right hand side of the figure, when observable swings in power are already relatively large, the added suspicion that *unobservable* shifts in power are also occurring via the potential presence of secret alliances is often enough to motivate opponents to attempt preventive conflict. Indeed, in this area of the figure we observe that secret alliances are associated with substantially increased probabilities of disputes relative to the baseline scenario.[78]

To further support our theory, we present several additional models designed to address alternative theories that are otherwise consistent with our initial empirical results. Table 2 displays the results of these alternative specifications. The first possibility we consider relates to strategic selection. Perhaps states form secret alliances when they anticipate imminent attack. Although announcing these alliances might reduce the risk of conflict by deterring potential adversaries, states may prefer to keep the alliances secret in order to reap tactical advantages once war begins in earnest,

[78] With the exception of *Joint Democracy,* the direction and significance of our control variables are also consistent with our predictions across all specifications.

Figure 3: Probability of disputes conditional on *Power Shifts* and *Secret Alliances*

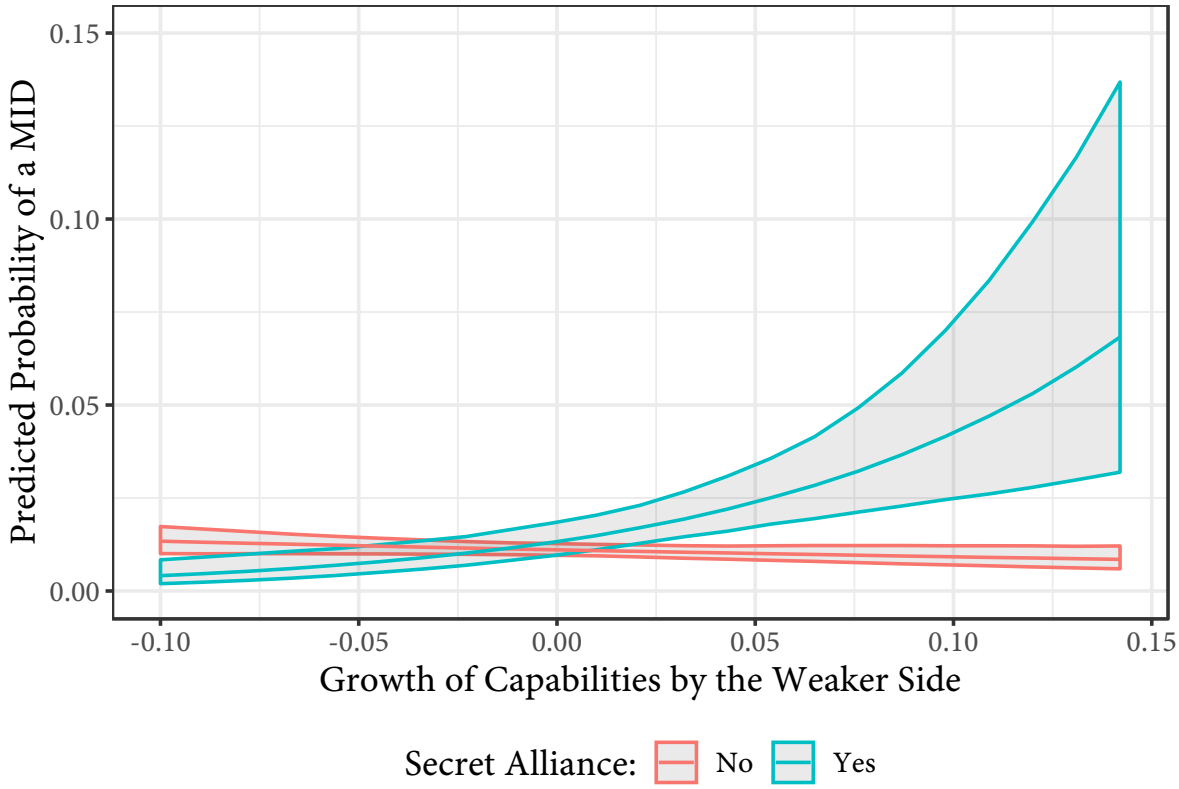


Figure 3 plots the predicted probability a MID occurs in a given dyad-year using estimates from model (5) in Table 1. Shaded regions depict 95% confidence intervals.

Table 1: Secret Alliances, Power Shifts, and MIDs

	Power Shift Duration				
	(1) *1 year*	(2) *2 years*	(3) *3 years*	(4) *4 years*	(5) *5 years*
Secret Alliances × Power Shift	18.64***	17.68***	15.36**	14.65***	13.91***
	(5.537)	(5.032)	(5.010)	(4.276)	(4.197)
Secret Alliance	0.438**	0.353*	0.311*	0.219	0.187
	(0.140)	(0.156)	(0.156)	(0.155)	(0.164)
Power Shift	-4.188	-4.900**	-3.005	-1.861	-1.876
	(2.262)	(1.622)	(1.579)	(1.407)	(1.270)
Relative Capabilities	1.697**	1.797**	1.637**	1.476*	1.486*
	(0.573)	(0.586)	(0.580)	(0.581)	(0.599)
Contiguity	0.793***	0.763***	0.739***	0.675***	0.684***
	(0.182)	(0.182)	(0.181)	(0.181)	(0.182)
Joint Democracy	-0.0809	0.0148	0.106	0.134	0.227
	(0.258)	(0.244)	(0.232)	(0.227)	(0.220)
Allied Dyad	-0.715***	-0.654**	-0.627**	-0.606**	-0.600**
	(0.217)	(0.214)	(0.214)	(0.214)	(0.220)
Peace Years	-0.154***	-0.161***	-0.172***	-0.178***	-0.181***
	(0.0155)	(0.0163)	(0.0171)	(0.0174)	(0.0174)
Constant	-3.117***	-3.039***	-2.902***	-2.757***	-2.731***
	(0.164)	(0.178)	(0.185)	(0.188)	(0.195)
Observations	24056	23318	22666	22044	21455

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Models use logistic regression with non-directed politically relevant dyad years as the unit of analysis
Dyad-clustered standard errors are shown in parentheses. Results for higher-level *Peace Years* are not shown.

as we alluded to earlier in our discussion of Slantchev (2010) and Lindsey (2015).[79] If this were the case and if power shifts directly increase the probability of conflict, then the creation of secret alliances in the prelude to such conflicts might explain the relationship we observe. To address this possibility, Model (6) drops all observations in which at least one state signed a secret alliance that year or in the previous two years. The results remain consistent with our hypothesis. Because the secret alliances that remain in this sample were forged at least three years prior to the initiation of a dispute, it is harder to believe that they were crafted by allies who were wary of imminent attack.

A second possibility is that rising states form secret alliances in hopes of carrying out attacks against their adversaries.[80] If such allies consistently delay their intended attacks while their capabilities mature, this behavior may produce the pattern we observe in the results—either in place of or alongside our *War of Suspicion* mechanism. Model (7) therefore limits our measure of *Secret Alliances* to include only those agreements that are purely defensive in nature. Despite this restriction, the results remain consistent with our predictions. Although not shown in the table, our results are also consistent when we combine the restrictions of models (6) and (7), thereby limiting our observations to cases in which new alliances were not formed in the three years preceding a conflict and limiting our *Secret Alliances* variable to measure purely defensive alliances. That we find support for our hypothesized relationship even among relatively lengthy defensive alliances increases our skepticism of the mutual optimism explanation for such conflicts. If states did not form defensive alliances out of concern of *imminent* attack by an adversary, it is curious why they would make no effort to reveal their alliance once conflict appeared likely. Revealing such an agreement should lower the opponent's expectation of victory or raising its anticipated costs for fighting, thereby reducing the opponent's willingness to fight and allowing the allies to avoid war. If wars nevertheless occur in these circumstances, states must harbor and incentive not to reveal their alliances even when conflict appears likely. Our theory helps to explain this puzzle: revealing an alliance might intensify

[79] Note that neither of these theories were designed with secret alliances in mind, though Slantchev (2010) acknowledges their potential applicability. As such, neither theory provides a clear explanation for why alliances formed immediately in the prelude to conflict would remain credible. If attack is certain, a third party who forms an alliance with a targeted state will be forced to suffer the costs of conflict if it honors the alliance, whereas it could conceivably avoid these costs by remaining neutral.

[80] For a discussion of secret offensive alliances, see Ritter (2003).

rather than reduce the opponent's incentive to attack by revealing definitively that two states that previously appeared independent are not only allied but on a rapid development trajectory. In these circumstances, allies would prefer to keep the alliance secret and risk a *war of suspicion* rather than reveal the alliance and abandon the possibility of peace entirely.

Our last two checks relate to the coding of our outcome and treatment variables. One concern is that our theory predicts preventive military action rather than merely the advent of a military dispute. As such, model (8) adopts an alternative dichotomous outcome variable in that assumes a value of "1" only if a dispute escalates to the use of military force. With this setup, the predicted relationship remains consistent with our hypothesis. The final alternative specification relates to the binary nature of our *Secret Alliance* variable. Although Bas and Schub use the same dichotomous measure in their article, they also construct a continuous variable that indicates the degree to which the secret alliances present in a dyad are collectively stronger (values >1) or weaker (values <1) than opponents would assume if such alliances existed only at baseline levels. In model (9) we substitute this continuous measure of alliance strength for our original dichotomous measure and find that the results continue to align with our predictions.

Overall the relationship between *Secret Alliances, Power Shifts,* and international conflict remains strong and consistent across a wide range of model specifications that address alternative theoretical explanations. Although secret alliances are far from the only example of clandestine military activities that could yield significant power shifts and provoke *Wars of Suspicion* by concerned adversaries, we believe these results provide plausible support for our theory as well as preliminary evidence to support the empirical commonality of the mechanisms we outline.

Table 2: Robustness and Alternative Specifications

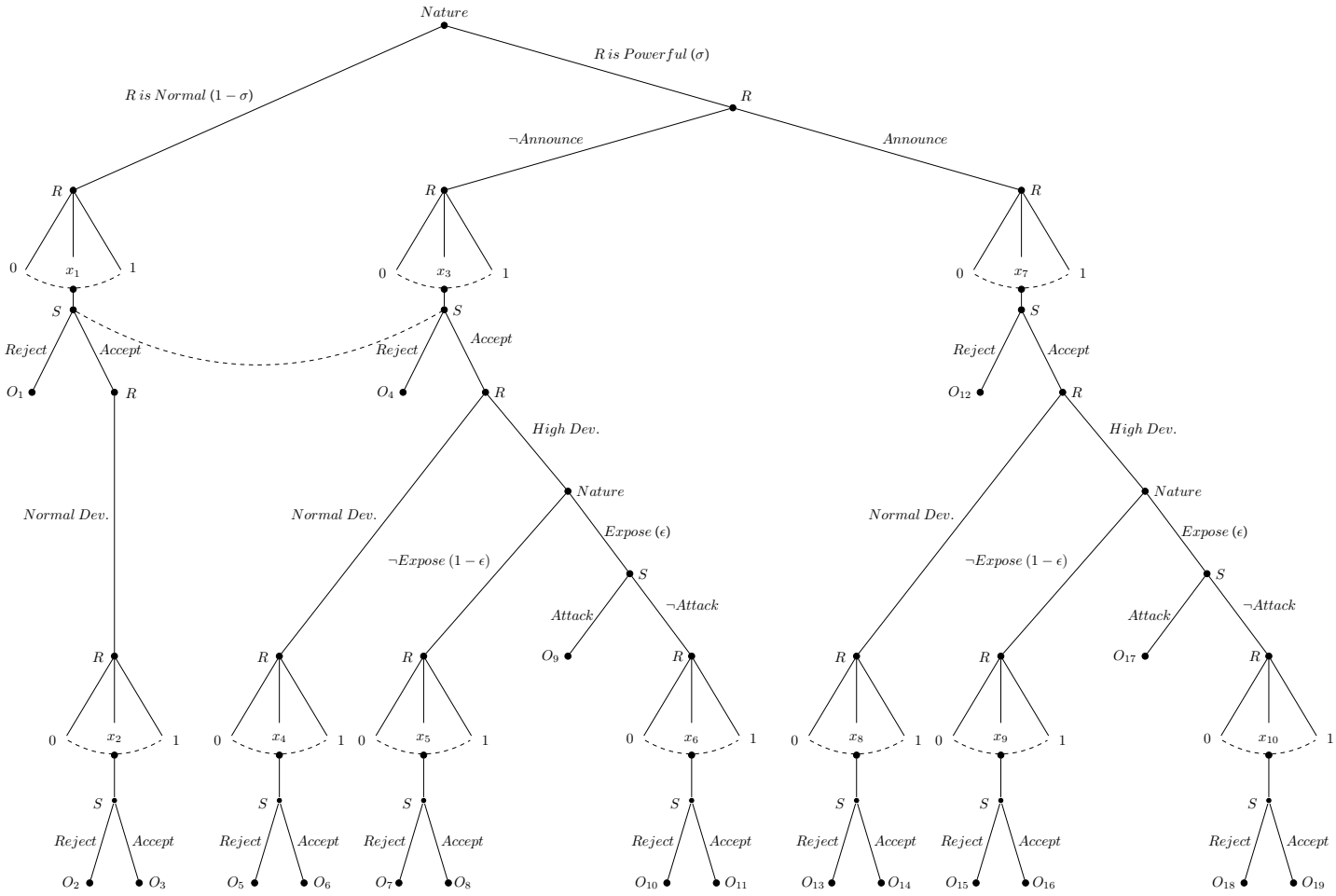
	(6) *Non-Recent*	(7) *Defensive*	(8) *Actual Force*	(9) *Continuous*
Secret Alliances × Power Shift	13.96*	10.41*	10.92*	6.752*
	(5.977)	(5.215)	(5.494)	(3.316)
Secret Alliance	-0.0677	0.153	0.192	0.338
	(0.376)	(0.167)	(0.217)	(0.207)
Power Shift (5 years)	-1.088	-0.784	-2.331	-4.923*
	(1.187)	(1.216)	(1.664)	(2.192)
Relative Capabilities	1.453	1.695**	1.113	1.782**
	(0.869)	(0.560)	(0.696)	(0.564)
Contiguity	0.655*	0.665***	0.726***	0.725***
	(0.258)	(0.180)	(0.205)	(0.189)
Joint Democracy	0.462	0.268	0.232	0.248
	(0.534)	(0.221)	(0.248)	(0.225)
Allied Dyad	-0.894**	-0.616**	-0.844**	-0.593**
	(0.335)	(0.223)	(0.262)	(0.221)
Peace Years	-0.203***	-0.181***	-0.234***	-0.180***
	(0.0045)	(0.0174)	(0.0221)	(0.0174)
Constant	-2.710***	-2.732***	-2.885***	-3.047***
	(0.274)	(0.194)	(0.221)	(0.261)
Observations	13643	21455	21455	21455

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Models use logistic regression with non-directed politically relevant dyad years as the unit of analysis and dyad-clustered standard errors in parentheses. Results for higher-level *Peace Years* are not shown.

Appendix B: Combined Model Depiction

Signaling and Development Model



Note: R's development matures and information becomes public prior to the second round of bargaining.

Appendix B lists the payoffs associated with each outcome (O_i).

Appendix C: Model Payoffs

Outcomes 1-19 refer to the enumerated nodes depicted in the combined figure (Appendix A).

Outcome:	Player R's Payoff:
O_1:	$p - C_R + \delta(p)$
O_2:	$x_1 + \delta(p + D - C_R)$
O_3:	$x_1 + \delta(x_2)$
O_4:	$p + \pi - C_R + \delta(p + \pi)$
O_5:	$x_3 + \delta(p + \pi + D - C_R)$
O_6:	$x_3 + \delta(x_4)$
O_7:	$x_3 + \delta(p + \pi + \Delta - C_R - K)$
O_8:	$x_3 + \delta(x_5 - K)$
O_9:	$x_3 + \delta(p + \pi - C_R - K)$
O_{10}:	$x_3 + \delta(p + \pi + \Delta - C_R - K)$
O_{11}:	$x_3 + \delta(x_6 - K)$
O_{12}:	$p + \pi - C_R + \delta(p + \pi)$
O_{13}:	$x_7 + \delta(p + \pi + D - C_R)$
O_{14}:	$x_7 + \delta(x_8)$
O_{15}:	$x_7 + \delta(p + \pi + \Delta - C_R - K)$
O_{16}:	$x_7 + \delta(x_9 - K)$
O_{17}:	$x_7 + \delta(p + \pi - C_R - K)$
O_{18}:	$x_7 + \delta(p + \pi + \Delta - C_R - K)$
O_{19}:	$x_7 + \delta(x_{10} - K)$

Outcome:	Player S's Payoff:
O_1:	$1 - p - C_S + \delta(1 - p)$
O_2:	$(1 - x_1) + \delta(1 - p - D - C_S)$
O_3:	$(1 - x_1) + \delta(1 - x_2)$
O_4:	$1 - p - \pi - C_S + \delta(1 - p - \pi)$
O_5:	$(1 - x_3) + \delta(1 - p - \pi - D - C_S)$
O_6:	$(1 - x_3) + \delta(1 - x_4)$
O_7:	$(1 - x_3) + \delta(1 - p - \pi - \Delta - C_S)$
O_8:	$(1 - x_3) + \delta(1 - x_5)$
O_9:	$(1 - x_3) + \delta(1 - p - \pi - C_S)$
O_{10}:	$(1 - x_3) + \delta(1 - p - \pi - \Delta - C_S)$
O_{11}:	$(1 - x_3) + \delta(1 - x_6)$
O_{12}:	$1 - p - \pi - C_S + \delta(1 - p - \pi)$
O_{13}:	$(1 - x_7) + \delta(1 - x_8)$
O_{14}:	$(1 - x_7) + \delta(1 - p - \pi - D - C_S)$
O_{15}:	$(1 - x_7) + \delta(1 - p - \pi - \Delta - C_S)$
O_{16}:	$(1 - x_7) + \delta(1 - x_9)$
O_{17}:	$(1 - x_7) + \delta(1 - p - \pi - C_S)$
O_{18}:	$(1 - x_7) + \delta(1 - p - \pi - \Delta - C_S)$
O_{19}:	$(1 - x_7) + \delta(1 - x_{10})$