*When Do Power Shifts Lead to War?**

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We present and test a choice-theoretic model of war decisions during shifts in power. The model assumes a rising state that overtakes a declining state in capabilities. In equilibrium, the declining state yields at a critical point in the transition. War can occur only before that critical time. Power shifts are more likely to lead to war as the challenger becomes more risk-acceptant, the declining state more risk-averse, the expected costs of war decrease, the rising state's dissatisfaction with the status quo increases, and during periods of equality between the two sides. The rate of growth of the rising state's capabilities and the transition point do not affect the probability of war. All these hypotheses are supported by an empirical analysis of all major power dyads since 1815. We also find that expected support from allies must be included in the calculation of a nation's capabilities. The implications of the model for theories of hegemonic decline and war are discussed.

The history of Europe flows with the rise and decline of major powers, punctuated by power transitions. Power transitions occur when a challenger surpasses the dominant state in material capabilities. Such shifts signal the likelihood of changes in the status quo established by the dominant state. The challenger may resort to war to achieve those changes. Many (Gilpin 1981; Kugler and Organski 1989; Modelski 1983; Organski 1968; Organski and Kugler 1980) believe that power transitions cause cataclysmic general wars.

Not all power transitions lead to wars. Houweling and Siccama (1988) found that transitions among the three or four most powerful nations led to war slightly less than half of the time (eight out of 17 cases in their Table 8, p. 101). This observation raises the question, when do *shifts* in power lead to war? By power shifts we mean predictable, long-run changes in relative capabilities as opposed to transitions, the moment when one nation's capabilities surpass another's. We analyze how relative growth in power can lead to war at any moment in time, not just at the transition point. We state a formal argument that distinguishes between power shifts that end in war and those that pass peacefully. We present evidence that the argument predicts the outcome of historical shifts.

When rising powers strike and why declining states resist is the focus of our analysis. Power shifts force sides to confront when to fight as well as whether to fight. We assume that nations respond to the international environment. One state begins with greater capabilities than the other; the status quo reflects its superior

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capabilities. As the rising state's power grows, war becomes more attractive to it and less attractive to the declining state. At some point, the declining state yields to the rising power, allowing the rising power to shape the status quo. After that time, the rising power continually makes demands to change the status quo. The once-superior state always grants the demands, a situation that both sides anticipate. Before then, war occurs only if both sides believe the benefits from gaining an early decision to their conflict outweigh its costs.

Our answer to the question of when power transitions end in war centers on the willingness to take risks. Risk-acceptant rising powers are willing to go to war earlier in the transition period than other rising powers are to transform the status quo sooner. Risk-averse declining states are more likely to resist such challenges than other declining states are to preserve their position longer.[1]

Theories of general war concentrate on power transitions between the most powerful state in the system and its immediate challenger. This leaves very few cases for analysis; Organski's power transition theory addresses five power transitions in the history of modern Europe. The logic of overtaking presented here applies to all shifts in power, not just the ascent of a new dominant state. We expand the set of test cases by examining all major power dyads. Time periods where the rising state did not overtake the declining state are included because our argument concludes that rough equality and not transitions per se make war likely. Unlike other tests of power transition theory (except for W. Kim 1989, 1991, 1992), we add the assistance that nations expect from their allies in the calculation of their capabilities.

Power Transitions, Preventive War, and Rational Choices

Differential rates of growth of capabilities drive the rise and decline of great powers. Industrialization, demographic growth, and increases in the state's ability to extract resources from its population lead to increases in a nation's capabilities (Organski 1968). The financial burdens of foreign commitments and a large military establishment (Gilpin 1981; Kennedy 1987), the need to service substantial debts from prior wars, and the failure to dominate new leading economic sectors (Thompson 1988, 112–66) slow the growth of a nation's capabilities.

[1]There are several aspects of power transitions we do not analyze here. First, dominant states have many responses to decline (Gilpin 1981, chap. 5). They could form alliances, invest in their economies, build up their arsenals, or retrench their position. Our argument addresses only the last possibility. (Our empirical analysis includes support from allies in the estimation of capabilities.) Second, we do not analyze the consequences of differences in the sides' perceptions of the changing balance. Misperceptions could make war more or less likely depending on whether the sides overrate or underrate their power (Morrow 1989a; Stein 1982). Without the assumption that nations always overrate their own capabilities, the effect of their perceptions is indeterminate. Finally, we do not ask the question of why dominant states do not crush nascent challengers far in advance of their rise to power. The literature, to our knowledge, has never addressed this question, so we do not.

Power transitions occur as those nations rising in power surpass those in relative decline.

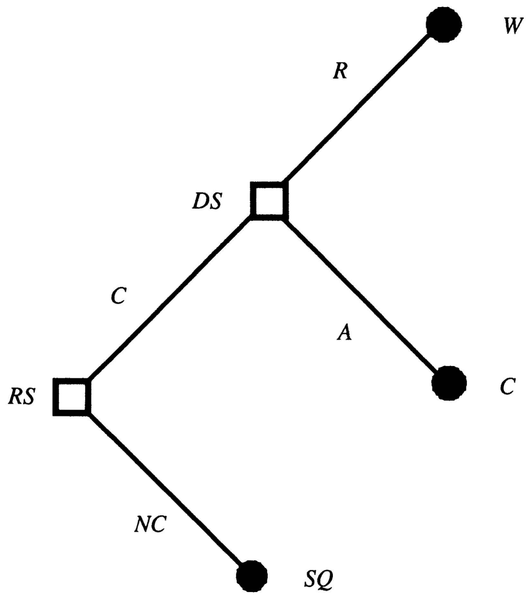
The international status quo does not change as rapidly as capabilities. It reflects the interests of a declining state more closely than those of a rising state. Both sides must consider the long-run implications of the growth of the rising state's power. The rising state must wonder whether now is the time to test its growing capabilities, and the declining state must wonder whether to resist a challenge. The longer they wait, the stronger the rising state becomes and the more willing it is to test its strength and the less willing the declining state is to resist. If the rising state waits, it must continue to suffer with the current status quo.

War occurs only if both the rising and the declining states are willing to fight. A nation's willingness to fight depends on its relative capabilities, what the alternative to war is, and its willingness to take risks (Bueno de Mesquita and Lalman 1986; Morrow 1985, 487–88). Greater capabilities relative to its opponent increases a nation's chance of victory and so its willingness to fight. When the alternative to war is unfavorable to a side, its willingness to fight increases. Because war is risky (i.e., neither side can predict the outcome when they go to war), greater willingness to take risks makes war more attractive. Some nations value victory highly, creating a willingness to take risks. Others fear defeat, producing an aversion to the risk of war.

The rising state's growing power forces both sides to consider when war would be advantageous. Both sides must be willing to fight for war to occur. We model these decisions as a game of timing. There are two actors, labeled *RS* and *DS* for rising state and declining state. The game tree in Figure 1 specifies the sequence of the actors' decisions at each instant during the game. The rising state must decide whether or not to contest the status quo (actions *C* and *NC* in Figure 1). If it does not, the status quo stands (the *SQ* outcome). If the rising state challenges the status quo, the declining state must decide whether to resist (action *R*) or acquiesce (action *A*). If the declining state acquiesces, it grants sufficient concessions to the rising state to end the immediate dispute (the *C* outcome); if it resists, war begins (the *W* outcome). The sides' payoffs for these outcomes change as the game progresses, and the rising state's capabilities increase relative to the declining state's.

The sides play until war occurs or the power transition ends. We assume the transition begins at $t = -1$ and ends at $t = 1$ with the two sides equal in capabilities at $t = 0$. If no challenge is made or a challenge is acquiesced to, the game continues. War ends the game and fixes the outcome for the remainder of the period. According to Gilpin (1981, 198), "The war determines who will govern the international system and whose interests will be primarily served by the new international order. The war leads to a redistribution of territory among the states in the system, a new set of rules of the system, a revised international

Figure 1. Game Tree of a Challenge



Key:
Boxes are decision nodes; dots are terminal nodes.
Actors: *RS* = rising state; *DS* = declining state.
Actions: *C* = challenge; *NC* = not challenge; *A* = acquiesce; *R* = resist.
Outcomes: *SQ* = status quo; *C* = concessions; *W* = war.

division of labor, etc." Like Gilpin, we assume that war resolves the issues in dispute. War also imposes costs on both players.

The rising state's decision to contest the status quo depends on the response it anticipates. If the declining state is expected to acquiesce, the rising state makes a demand. If the declining state will resist, the rising state contests the status quo if it prefers war to the status quo. We begin with the declining state's decision whether to resist a challenge.

When faced with a challenge, the declining state weighs the relative attraction of fighting versus submitting. War is costly and fixes the outcome for the remainder of the transition; submission requires concessions now and leaves open the possibility of more demands from the rising state later. As the declining state's capabilities decline, its chance of winning a war decreases. War becomes less attractive to the declining state as the transition progresses because war fixes a less desirable outcome for it.

At some point, fighting and submitting are equally attractive. From then on, the declining state prefers to submit because fighting becomes less attractive as its capabilities continue to decline. The rising state always contests the status quo after the declining state submits to a challenge. It anticipates that the declining state will yield. If the declining state acquiesces to a challenge, it will have to make a stream of concessions in the future. We assume these concessions at any particular moment equal the policy outcome it sees as equivalent to the policy outcome of war at that time. We refer to the time when the declining state is indifferent between fighting and submitting as its *critical point*. The declining state resists all earlier challenges; it acquiesces to all later challenges.

Each side's evaluation of the policy consequences of a war depends upon the possible policy outcomes, the actors' preferences over those outcomes, and the likelihood of those outcomes occurring. We draw on Morrow (1985, 1986). The actors have opposed interests. The interval [0, 1] represents the possible outcomes of the issues at stake; one denotes the resolution of the issues the rising state would impose after a total victory; zero, the policy consequences of a total victory for the declining state; and all points in between, more moderate resolutions of the issues. The larger the outcome, the more it favors the interests of the rising state.

Each side's utility for a policy outcome is a function of that outcome and its risk attitude. Formally,

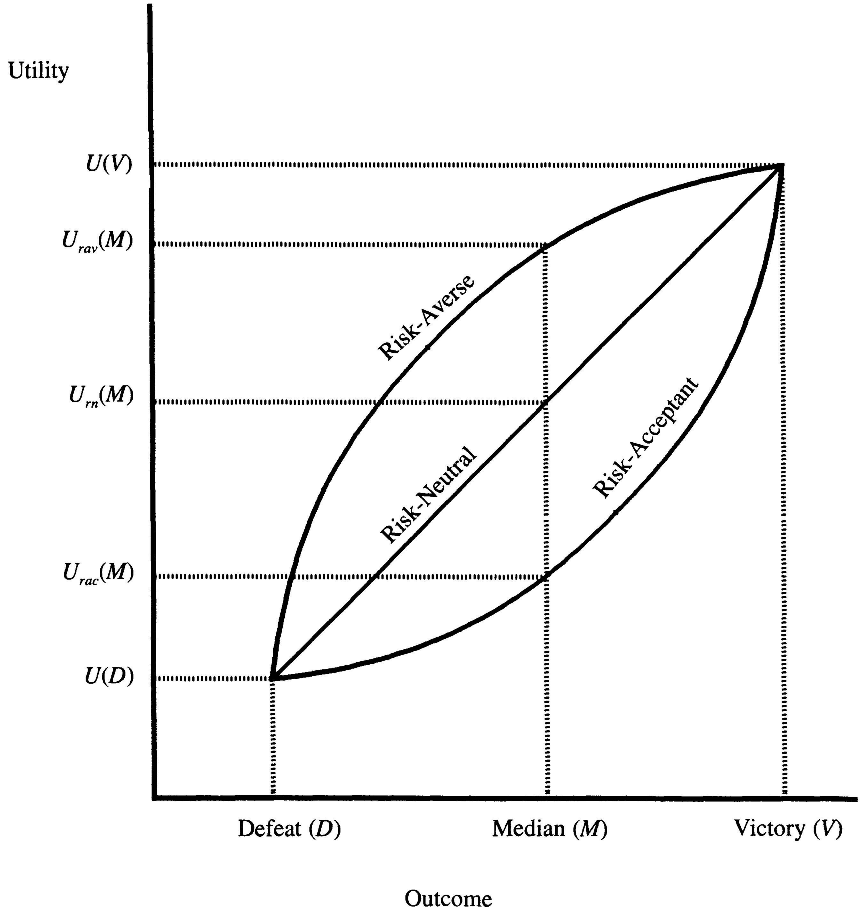
$$u_{RS}(x) = x^{rRS} \qquad u_{DS}(x) = 1 - x^{(1/rDS)},$$

where rRS and rDS give the risk attitudes of the rising state and the declining state. The rising state prefers higher outcomes, and the declining state, lower outcomes; $(du_{RS})/dx > 0$ and $(du_{DS})/dx < 0$. The curvature of a nation's utility function reflects its willingness to take risks (Morrow 1987).[2] Values of $r = 1$ indicate risk-neutrality; $0 < r < 1$, risk-aversion; and $r > 1$, risk-acceptance. Risk-neutral utility functions are linear; risk-averse utility functions bow upward; and risk-acceptant utility functions bow downward as pictured in Figure 2.

The status quo is $SQ \in [0, 1/2)$ when the transition begins. This initial status quo favors the declining state as $SQ < 1/2$. Each side's utility for the outcomes is assumed to remain fixed over the period of the transition. Rational actors weigh their chance of prevailing and their value for what is at stake when considering war. A probability distribution over the outcomes gives the former, and a utility function over the outcomes specifies the latter (Bueno de Mesquita 1981; Morrow 1985). A nation's expected utility for the policy outcome of a war is the sum over all possible outcomes of the product of its utility for an outcome times

[2]Technically, curvature is not a measure of risk attitude. The expression $u''(x)/u'(x)$ measures the risk attitude of utility function $u(x)$ (Pratt 1964). Curvature is $(u''(x)/((1 + [u'(x)]^2)^{3/2})$. However, curvature does provide an intuitive feel for risk attitudes that $u''(x)/u'(x)$ cannot.

Figure 2. Three Utility Functions with Different Risk Attitudes



the probability of that outcome occurring. A nation's *equivalent outcome for war* is the outcome equal in utility to its expected utility for the policy outcome of a war. Equivalent outcomes for war give the minimal settlement that a side will accept in lieu of war.

Shifts in power affect these calculations by shifting the probability distribution over time. The rising state's chance of prevailing in a war increases, and the declining state's chance falls as the rising state's capabilities grow relative to the declining state's. If war occurs, the outcome is determined by a probability distribution that depends upon when during the transition the war occurs and the growth rate of the rising state's capabilities. We assume the probability distribution of outcomes is

$$p(x; t, g) = 1 - \left(\frac{g}{2}\right)t + gtx,$$

where $t \in [-1, 1]$ gives the time during the transition; $g \in [0, 2]$ gives the relative growth rate of the rising state's capabilities; $g = 0$ means the rising state's capabilities do not grow relative to the declining state's during the period; and $g = 2$ is maximum growth. As the transition progresses, the rising state's chance of winning a war increases. The higher the relative growth rate of the rising state, the steeper the increase in its probability of victory over time.[3]

The rising state's expected utility for war is calculated by integrating across all outcomes the product of the probability of each outcome by the rising state's utility for that outcome:

$$\begin{aligned} E(U_{RS})\,(t) &= \int_0^1 \left(1 - \frac{gt}{2} + gtx\right)x^{rRS}\,dx \\ &= \frac{1}{rRS + 1} + \frac{gt(rRS)}{2(rRS + 1)\,(rRS + 2)}. \end{aligned} \tag{1}$$

Expression (1) gives the rising state's utility for its equivalent outcome for war. The declining state's expected utility for war is calculated similarly:

[3]We treat the decision problem of when to strike under the condition of risk. We assume both sides have the same forecast of their future growth and that common forecast is accurate. Friedberg (1988) differentiates between assessing a change in capabilities and adapting to it. Here we hold the problem of assessing change constant while examining the question of adaptation to it.

We do not consider any of the many uncertainties in a power transition (Levy 1987, 101–03, discusses possible uncertainties in power transitions) and how the sides might judge those uncertainties differently for two reasons. First, we derive a number of interesting hypotheses without complicating the analysis by adding uncertainty. Second, unless the sides systematically deviate in their perceptions of those uncertainties, the effect of perception seems indeterminate. Either side could overrate or underrate their future chances, making either more or less willing to fight. Organski (1968, 373–74) argues that challengers overrate their future growth because their rapid growth deceives them. But this argument is ad hoc: it seems equally plausible that challengers underrate their future growth because they do not believe they can sustain their incredible growth in capabilities. We do not argue that the differences between perceptions and reality are unimportant. Nor do we accept the position that rational choice is incapable of dealing with the question of misperception (for an example of how misperception can be treated in game theory, see Morrow 1989a). Rather we believe the approach adopted here provides an important first step to understanding the consequences of shifts in power.

The probability distribution is stylized for computational ease. It assumes that the final relative capabilities of the rising state are determined by its growth rate. This assumption could be problematic because the growth rate determines the concessions the rising state receives from the declining state at $t = 1$.

$$E(U_{DS})\,(t) = \int_0^1 \left(1 - \frac{gt}{2} + gtx\right)[1 - x^{(1/rDS)}]\,dx = \frac{1}{rDS+1} - \frac{gt(rDS)}{2(rDS+1)\,(2rDS+1)}. \tag{2}$$

Expression (2) also gives the declining state's utility for its equivalent outcome for war.

The declining state resists a challenge when its utility for resisting minus the costs of war exceeds its utility for submitting to the challenge. If it resists, the outcome is fixed at the result of the war for the remainder of the transition. If it submits, the rising state challenges at all future times, and the declining state submits to those challenges. The declining state's expected utility for resisting a challenge is its utility for the equivalent outcome for war at that moment times the remaining time in the transition minus the costs of war. The declining state's utility for submitting equals the integral of its expected utilities for war across the remainder of the transition. The declining state resists at time t when the following is true:

$$\begin{aligned}(1-t)E(U_{DS})\,(t) - C &\geqslant \int_t^1 E(U_{DS})\,(s)ds \\ (1-t)\left[\frac{1}{rDS+1} - \frac{gt(rDS)}{2(rDS+1)\,(2rDS+1)}\right] - C &\geqslant \int_t^1 \frac{1}{rDS+1} - \frac{gs(rDS)}{2(rDS+1)\,(2rDS+1)}\,ds,\end{aligned} \tag{3}$$

where $c > 0$ gives the utility of the physical destruction of war. Calculating the integral and solving for t, we arrive at the following:

$$t \leqslant 1 - \left[\frac{4C(rDS+1)\,(2rDS+1)}{g(rDS)}\right]^{1/2}. \tag{4}$$

The point of equality of expression (4) gives the declining state's critical point, t_{crit}. It resists challenges made before t_{crit} and submits to those made after t_{crit}.[4]

What determines this critical point? Taking partial derivatives shows that t_{crit} increases as C decreases, g increases, and rDS decreases.[5] First, the lower the

[4]The other root of expression (4) is ignored because it falls outside the transition period.

[5]The partial derivatives are

$$\frac{\partial t_{crit}}{\partial C} = -\frac{1}{2C}\left[\frac{4C(rDS+1)\,(2rDS+1)}{g(rDS)}\right]^{1/2} < 0$$

$$\frac{\partial t_{crit}}{\partial g} = \frac{1}{2g}\left[\frac{4C(rDS+1)\,(2rDS+1)}{g(rDS)}\right]^{1/2} > 0$$

expected costs of war, the later during the transition the critical point occurs. The declining state prefers submitting to fighting when the expected cost of war exceeds the difference between the equivalent outcome for war and the flow of future concessions from submitting. This difference shrinks as the transition progresses because the declining state's equivalent outcome for war deteriorates over time. The lower the costs, the later in the transition the declining state is willing to resist a challenge.

Second, the higher the growth rate of the rising state's capabilities relative to the declining state, the later the critical point. The value of yielding to a challenge equals the future stream of the declining state's equivalent outcomes for war. A faster decline in equivalent outcomes increases the difference between the current equivalent outcome for war and the stream of those values in the future. A swifter decline enlarges the difference between fighting now and submitting from now on, increasing the declining state's willingness to resist. The higher the rising state's relative growth rate, the faster the fall in the declining state's probability of victory and its equivalent outcome from war. Higher rates of decline cause the declining state to be willing to resist later in the transition.

Third, the more risk-acceptant the declining state, the sooner the critical point occurs. Risk-averse declining states' expected utility for war declines more rapidly than that of risk-acceptant declining states across the entire transition. Return to Figure 2. The utility function of a risk-acceptant actor rises most steeply in the region of victories, the outcomes between the median, *M,* and victory, *V,* in Figure 2. The utility function of a risk-averse actor rises most steeply over defeats, outcomes between defeat, *D,* and the median, *M,* in Figure 2. During a power transition, the likely outcome of a war shifts from victory for the declining state to defeat. In the range of defeats, the expected utility of a risk-averse declining state drops rapidly as the likely outcome of a war becomes worse for it. This rapid drop, reflected in the slope of the risk-averse utility function in the range of defeats, provides risk-averse declining states with a motivation to fight. The utility function of a risk-acceptant declining state falls off more slowly in the range of defeats. It sees little reason to fight; the stream of concessions in the future is not much worse than the prospect of fighting now. When risk-averse declining states must decide whether to resist a challenge, they anticipate a greater future loss in utility than risk-acceptant actors. As with greater growth

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$$\frac{\partial t_{crit}}{\partial rDS} = \frac{2C(1 - 2rDS^2)}{g(rDS)^2}\left[\frac{4C(rDS + 1)(2rDS + 1)}{g(rDS)}\right]^{-1/2} < 0 \quad \text{if} \quad rDS > \sqrt{1/2}.$$

The third partial is positive for extremely risk-averse states ($0 < rDS < \sqrt{1/2}$). Among extremely risk-averse declining states, the greater their risk-aversion, the later their critical time occurs. We do not test for this inversion in our hypothesis because it occurs only for extreme values, and it may be a product of the particular probability distribution and utility functions assumed here.

rates, the anticipation of greater future loss leads risk-averse declining states to resist challenges further into the transition than risk-acceptant actors.[6]

We summarize these results in the following proposition:

PROPOSITION 1: The declining state's critical time, the point at which it is indifferent between war and acquiescing to a challenge, occurs later in the transition (all else equal)
(a) the less the costs of war,
(b) the greater the relative growth rate of the rising state, and
(c) the greater the risk-aversion of the declining state.

The rising state's choice between contesting and accepting the status quo depends on the declining state's reaction. If the declining state will submit, the rising state always challenges. If the declining state will resist, the rising state contests the status quo only when its utility for war exceeds its utility for waiting. War fixes the outcome for the remainder of the transition. The rising state's utility for war is its expected utility for war times the remaining time in the transition ($1 - t$ from time t) minus the costs of war ($C > 0$, the utility of the physical destruction of war). Accepting the status quo leaves it intact for now but leaves open the possibility of future challenges. We assume that if the rising state waits, it does not challenge the status quo until the declining state's critical point, t_{crit}, at which time the declining state acquiesces. Waiting to challenge means that the status quo continues until t_{crit}, and then the rising state receives a stream of concessions equal to its expected utility for war across the remainder of the transition. The rising state's utility for not contesting the status quo then is the sum of two utilities: (1) its utility for the original status quo for the period from now until the declining state's critical point and (2) its utility for the stream of concessions the declining state makes after its critical point. The rising state contests the status quo at time t if its utility for fighting now exceeds its utility for waiting until the declining state's critical point.

$$(1 - t)E(U_{RS})\,(t) \geqslant (t_{crit} - t)u_{RS}(SQ) + \int_{t_{crit}}^{1} E(U_{RS})\,(s)ds$$

$$(1 - t)\left[\frac{1}{rRS + 1} + \frac{gt(rRS)}{2(rRS + 1)\,(rRS + 2)}\right] - C \geqslant \tag{5}$$

$$(t_{crit} - t)SQ^{rRS} + \int_{t_{crit}}^{1} \frac{1}{rRS + 1} + \frac{gs(rRS)}{2(rRS + 1)\,(rRS + 2)}\,ds.$$

[6]Risk-acceptance for the declining state, $-u''(x)/u'(x) > 0$, means that $u'(x) < 0$ (recall that *DS* prefers lower x's to higher x's) and $u''(x) > 0$. Its utility for defeats (larger x's) falls off more slowly than its utility for victories (smaller x's). A risk-averse declining state has $u''(x) < 0$, and its utility drops off more quickly for losing outcomes than winning outcomes.

When we integrate and rearrange terms, we arrive at the following inequality:

$$0 \geq 2At^2 + t(B - 2A) + A(1 - t^2_{crit}) - Bt_{crit} + C \tag{6}$$

$$\text{where } A = \frac{g(rRS)}{4(rRS + 1)(rRS + 2)} \text{ and } B = \frac{1}{rRS + 1} - SQ^{rRS}.$$

The above inequality can be solved using the quadratic formula. The two roots, if they exist, give the points where the right side equals zero. All values of t between the two roots satisfy inequality (6). War occurs when t_{crit} is greater than the larger of the two roots:

$$t_{crit} > 1/2 - \frac{B}{4A} + \frac{1}{4A}\sqrt{B^2 - 4AB(1 - 2t_{crit}) - 4A^2(1 - 2t^2_{crit}) - 8AC}. \tag{7}$$

The rising state prefers to strike at the center of the interval between the two roots, $1/2 - B/(4A)$. This time could be before or after the moment of equality, but it is generally found close to equality.

What conditions make the rising state more likely to fight? An appendix contains the formal analysis of expression (7). Here we summarize the conclusions of that analysis. First, the lower the costs faced by the rising state, the more willing it is to fight. The lower the costs of war, the less benefits are required to make war attractive. Second, the greater the rising state's dissatisfaction with the status quo, the more willing it is to fight. A less favorable status quo increases the cost of waiting to change it, making war more attractive. Third, a higher growth rate of the rising state's capabilities reduces its willingness to fight. The rising state's chance of winning in the future rises with its capabilities. A higher growth rate means greater gains in the future if the rising state waits. Not only is its chance of winning a war greater in the future, but the concessions it can extract from the declining state in lieu of war also increase. Fourth, the greater the rising state's willingness to take risks, the more likely it is to fight. Greater willingness to take risks raises the equivalent outcome of a war compared to the status quo. Unlike the declining state, the rising state compares war to the status quo. Risk-acceptant rising states should be more willing to fight than risk-averse rising states.

When does the rising state prefer war to waiting? Early in the transition, it waits because its chance of winning a war is too low. Close to the declining state's critical point, it waits because it soon will get what it wants without fighting. War is possible only when the rising state has a high enough probability of winning and the declining state's critical point is far enough in the future. When the two sides are roughly equal in power, a window opens where the rising state considers war. This window typically opens and closes before the point of equality. If the declining state's critical point occurs near the end of the transition, it can include the point of equality.

We summarize these results in the following proposition:

PROPOSITION 2: The interval where the rising state is willing to fight the declining state expands as
(a) the costs of war decrease,
(b) the rising state's dissatisfaction with the status quo increases,
(c) the relative growth rate of the rising state decreases, and
(d) the rising state becomes more risk-acceptant.

Putting the two propositions together, when do shifts in power make war more likely? First, risk-acceptant rising states and risk-averse declining states increase the chance of war. Second, the greater the rising state's dissatisfaction with the status quo, the more likely war is. Third, the lower the expected costs of war, the more likely war is. Lower costs encourage the declining state to resist challenges and push the declining state's critical point further into the future, increasing the rising state's motivation to fight. Fourth, war is more likely when the parties are roughly but not exactly equal in capabilities. Early in the transition, the rising state waits for a greater chance of winning. Late in the transition, the declining state yields to any challenge.

The model suggests that several factors have little effect despite their surface plausibility. The growth rate of the rising state's capabilities relative to the declining state makes little difference. Higher growth rates make the declining state more likely to resist and the rising state less likely to challenge. The actual transition point is not exceptionally dangerous.

We contrast our hypotheses with Organski's power transition theory in Table 1. We compare our model to power transition theory because it was the first theory that argued that power transitions cause wars and is the most fully developed of all those theories. Our model agrees with Organski that the rising state's dissatisfaction plays a major role in power transition wars. We disagree with him on the importance of growth rates and transition points. Power transition theory contends that war is most likely at the point of equality and that higher growth rates increase the chance of war (Organski 1968, 370, 373). Neither is important in our model. Organski is silent on the question of risk attitudes that is central to our model. Kugler and Zagare (1990) discuss the effect of risk attitudes on power transitions between nuclear powers. They conclude that war can occur only when one power is risk-acceptant and the other is risk-neutral or risk-acceptant. We agree with them that risk-acceptant rising states make war more likely. Contrary to their view, our hypotheses assert that risk-averse declining states make war more likely rather than impossible.

Table 1. Comparison of Power Transition Theory and Our Model

	Power Transition Theory	Our Model
War becomes more likely as. . .		
Transition points	Important	Irrelevant
Equality of capabilities	Increases implicitly	Increases
Rising state's relative growth rate	Increases	Irrelevant
Rising state's dissatisfaction	Increases	Increases
Rising state's risk attitude	Increases	Increases
Declining state's risk attitude	Increases	Decreases

Testing the Argument: Operationalization of Variables

We test our hypotheses by examining when shifts in power between great powers make war more likely. Our argument suggests that transitions in and of themselves are not dangerous, but rough equality does make war more likely. To test this hypothesis, we must look at cases where the sides are not equal. Consequently, we examine all power relationships between pairs of great powers during the period from 1816 to 1975. We take the definition of great powers from Small and Singer (1982, 38–51).

We create the set of test cases, following Organski and Kugler (1980), Houweling and Siccama (1988), and W. Kim (1989), by dividing the years from 1816 to 1975 into 20-year periods. A long time period is required to produce sufficient changes in the power distribution for the adversaries to consider that change as a reason for war. For each period, each great power is paired with every other great power. This creates 115 dyad-periods.[7] Table 2 gives the test periods, the great powers, and the number of dyads in each period.

Our objective is to separate empirically the dyad-periods that include a war between the dyad from those that do not. The dependent variable is a dichotomy of war or no war. The set of candidate wars is drawn from Small and Singer (1982, 78–99). We select wars from that set based on two criteria: (1) whether one or more major powers participated on each opposing side and (2) whether the opposing sides made all-out efforts to win the war. We do not consider wars

[7]This procedure decomposes disputes between the two groups of nations into all possible dyads. There are advantages and disadvantages to doing this. It increases the number of cases and avoids aggregating nations whose actions may be independent. On the other hand, it also isolates dependent decisions and increases the effects of random error in the measurement of the independent variables. For example, there are 21 dyads in the period from 1919 to 1939. The behavior of some nations in those dyads was not independent across dyads. Cases that are not statistically independent can be problematic in statistical tests. The significance tests used here should be viewed as a heuristic device to suggest the relative strength of associations. Decomposing multilateral disputes is not novel. Statistical analyses of arms race disputes often decompose multilateral disputes (see Morrow 1989b; Wallace 1979).

Table 2. Test Periods, Great Powers, and Number of Dyads

Test Periods	Great Powers	Number of Dyads
1820–39	UK, FRN, GMY, AUH, RUS	10
1840–59	UK, FRN, GMY, AUH, RUS	10
1860–79	UK, FRN, GMY, AUH, RUS, ITA	15
1880–99	UK, FRN, GMY, AUH, RUS, ITA	15
1900–13[a]	UK, FRN, GMY, AUH, RUS, ITA, USA, JAP	28
1919–39[a]	UK, FRN, GMY, RUS, ITA, USA, JAP	21
1946–55	UK, FRN, RUS, USA	6
1956–75	UK, FRN, RUS, USA, CHN	10

Note: The total number of dyads is 115.

[a]The years 1914–18 and 1940–45 were excluded from test periods because national capability scores are not available for those years. Dyads from the periods 1900–13 and 1919–39 are considered to end in war if the members of the dyad found themselves at war with one another in World Wars I and II, respectively.

with a major power on only one side nor wars where a major power combatant made only trivial efforts. We judge the second criterion by the severity of battle deaths or whether the losing side lost territory.[8] Seven wars satisfy these criteria (W. Kim 1989, 257–60; Organski and Kugler 1980, 45–47): the Crimean War, the War of Italian Unification, the Seven Weeks' War, the Franco-Prussian War, the Russo-Japanese War, World War I, and World War II. Of the 115 dyad-periods, thirty-one end in war.

We test the effect of six independent variables: (1) equality of capabilities between the two great powers in the dyad; (2) whether a power transition occurs between the two during the period; (3) the difference between the growth rates of the two; (4) the risk attitude of the weaker power; (5) the risk attitude of the stronger great power; and (6) the weaker power's dissatisfaction. Our argument asserts that the first, fourth, and sixth variables should have a positive effect; the fifth should have a negative effect; and the second and third should be insignificant.

Nations can augment their power through both internal and external means. The growth of a nation's economy and population and expansion of its military forces are two ways of increasing capabilities internally. Strengthening a nation's alliances and weakening opposing alliances are two external means of augmenting national capabilities. Our calculation of a nation's capabilities then must

[8]A referee wondered whether the results changed if this condition was dropped. They do not because there are only two wars between major powers not included, the Changkufeng and Nomohan incidents. The dyad-period that includes both these wars is coded a war period because the Soviet Union and Japan fought in World War II.

include both internal and external sources of capabilities. Otherwise, it provides a misleading picture of how the power relationship between the sides changes over time. W. Kim (1989, 1991, 1992) presents evidence that supports the use of the adjusted capabilities measure.

We synthesize in one measure both the internal and external capabilities on which a nation can draw. A nation's internal capabilities are given by its composite capability score developed by the Correlates of War project.[9] We add the support that nation expects from all other major powers. The support a particular third party contributes to a major power depends on its own capabilities and the closeness of relations between the two. Countries with greater internal capabilities have more to contribute, and those with better relations contribute a greater fraction of their capabilities.

Great powers *i*'s and *j*'s adjusted national capabilities are calculated as follows:[10]

$$\begin{aligned} AdjC_i &= C_i + \sum_{k \neq i,j} C_k \left[\frac{U_{ki} - U_{kj}}{2}\right] \quad \text{if} \quad U_{ki} - U_{kj} \geqslant 0 \\ AdjC_j &= C_j + \sum_{k \neq i,j} C_k \left[\frac{U_{kj} - U_{ki}}{2}\right] \quad \text{if} \quad U_{kj} - U_{ki} \geqslant 0, \end{aligned} \tag{9}$$

where *i* (or *j*) is great power *i* (or *j*) in each dyad; *k* is a third-party great power; $AdjC_i$ (or $AdjC_j$) is *i*'s (or *j*'s) adjusted national capability; C_i (or C_j or C_k) is *i*'s (or *j*'s or *k*'s) internal capability; and $(U_{ki} - U_{kj})/2$ gives the percentage of *k*'s capabilities that it contributes to *i*'s capabilities when $U_{ki} - U_{kj} \geqslant 0$.

Great power *i*'s adjusted capabilities, denoted $AdjC_i$, add the third-party support that *i* receives to its internal capabilities. Third parties' preferences between the policies of powers *i* and *j* determine the magnitude and direction of their contributions to *i*'s or *j*'s capabilities. The exact amount increases with the strength of the third-party's preferences. We measure intensity of preference by the tau-*b* measure of similarity of alliance profiles pioneered by Bueno de Mesquita (1981, 109–18).

An alternative measure simply adds the capabilities of a nation's allies to its own. Our adjusted capability measurement improves on this in two ways. First, the measure discounts a nation's expected support from its allies by the reliability of the alliance. Second, nations often expect aid from nonallies. Our measure

[9]Composite capabilities are based on six indicators of economic, demographic, and military capabilities. These six indices are iron and steel production, energy consumption, total population, urban population, military personnel, and military expenditures. A nation's composite capability is the average of its share of each of these six indices. Kennedy (1987, 198–202) uses these indices in his discussion of shifts in capabilities in the late nineteenth century.

[10]Bueno de Mesquita and Lalman (1986, 1992) use a similar measure of national capabilities. Unlike their measure, our measure restricts third parties to great powers only. A detailed description of the terms $(U_{ki} - U_{kj})$, U_{ki}, and U_{kj} can be found in Bueno de Mesquita (1981, 109–18).

includes these contributions by considering all third-party great powers as possible contributors. Altfeld and Bueno de Mesquita (1979) show that the difference in tau-*b* scores is related to nations' decisions to intervene in wars.

Our measures of the independent variables are based on adjusted national capabilities. We measure the equality of power in a dyad by the ratio of the two great powers' mean adjusted capability scores across each 20-year period. We average each power's adjusted capabilities across a period and divide the smaller of the two means by the greater to obtain this "alliance equality" ratio. It varies from zero to one, with the degree of equality of capabilities in the dyad increasing with its value.

A power transition occurs during a period if the nation that begins with fewer capabilities passes the other nation in the dyad by the end of the 20 years. When we use adjusted capabilities, we call this variable "alliance transition." When internal capabilities are used, we call it simply "transition." It is coded one if a transition occurs; otherwise, zero. An alliance transition occurs in 39 cases, a transition in 12 cases.

The rate of growth assesses the difference between the growth rates of the two nations' adjusted capabilities. First, we calculate the growth rate of each great power's capabilities. We divide each period into two 10-year halves and calculate each power's mean adjusted capabilities during each half. We then calculate each nation's growth rate from the first half of a period to the second.[11] We subtract the smaller growth rate from the greater to obtain the relative growth rate in the dyad.[12] If the growth rate of one power is fast and the other is slow, the difference is great. The difference is small when the growth rates of both are slow or fast. We call this variable "alliance growth rate" when adjusted capabilities are used and "growth rate" when internal capabilities are used. The average of alliance growth rate is .56 with a standard deviation of .59; the mean of growth rate is .38 with a standard deviation of .38.

We use the measure of risk attitudes first used in Bueno de Mesquita (1985) and explained in Morrow (1987). This measure assesses each great power's relative preference for security over autonomy embodied in its alliances. Risk-acceptant actors pursue autonomy at some cost in security. Risk-averse actors value security over autonomy and pursue alliances that produce a high level of

[11]The formula for calculating a nation's growth rate is $(AC_2 - AC_1)/(AC_1)$, where AC_1 is its mean adjusted capability for the first half of a period, and AC_2, its mean adjusted capability for the second half. We use 10-year averages rather than annual data to smooth out year-to-year variations in capabilities.

[12]Other measures of growth rate are also plausible. To test the robustness of our results, we constructed two other measures of relative growth rate. The first was the weaker power's growth rate minus the stronger's. The second was the growth rate of the ratio of capabilities of the two sides. We report our results with the indicator described in the text because we believe it is the most appropriate indicator of the three.

security. Both are measured by comparing the security that a nation's alliances provide to the maximum and minimum levels of security possible. Risk-acceptant great powers should have security close to their minimum level of security, and risk-averse states should have levels close to their maximum possible. The resulting scores run from −1 to 1, with higher scores indicating greater willingness to take risks. We calculate these scores for each year and average them across a 20-year period to measure a great power's risk attitude for that period.[13]

The classification of rising states and declining states is difficult at best. We begin with the simplest rule: rising states are weaker than declining states. The nation that begins a dyad-period with fewer capabilities is the rising state. We define two variables: "rising state's risk attitude" and "declining state's risk attitude." The mean risk score of the weaker side is −.24 with a standard deviation of .33; the average risk score of the stronger side is −.04 with a standard deviation of .33.

This classification produces two troubling problems. First in the model, the rising state can be stronger than the declining state if no challenge has been made yet. Our classification of rising states incorrectly judges the weaker power as the rising state in these cases. Second, there are cases where the stronger power's capabilities increase relative to the weaker's. Here it would be misleading to call the weaker power a rising state. Both problems occur when the stronger power is growing relative to the weaker. To correct for these problems, we introduce a dummy variable for the cases where the stronger power is growing relative to the weaker and examine its interaction with the risk variables.

We assess the rising state's dissatisfaction by the degree of agreement between its policies and those of the dominant state in the system (W. Kim 1991). The rising state's dissatisfaction increases as its policies diverge from the dominant state's. The great power with the greatest average internal capabilities is the dominant state in a 20-year period. For every other power, we calculate its average utility score for the dominant state's policies during the period. The higher this score, the greater the agreement between the two. "Dissatisfaction" is the score of the weaker power in a dyad times negative one. Its mean is .002 with a standard deviation of .30.

[13]The risk measure is biased (Morrow 1987, 434–37). Nations with low values for the status quo are assessed as less risk-acceptant than they are. Similarly, those with high values for the status quo are assessed as more risk-acceptant than they are. This bias works against the hypotheses on risk attitudes here. The lower the rising state's value for the status quo, the more likely it is to fight. But the estimates of the risk attitudes of challengers with a low value of the status quo is biased below their true value, and the risk scores of challengers that do go to war should be biased below their true value. This bias makes it more difficult to support the hypothesis that risk-acceptant challengers are more likely to go to war. The results in this paper then *understate* the strength of the relationship between risk attitudes and power transition wars.

Testing the Argument: Data Analysis

We estimate the effects of the different independent variables on the probability of war using logit analysis (Hanushek and Jackson 1977, chap. 7). Logit analysis estimates the effect of each independent variable on the logarithm of the odds ratio of the dependent variable using a maximum likelihood procedure.

We present the results of three analyses and discuss other runs to test the robustness of the results against alternative specifications and indicators of the variables. All three models examine the effect of transitions, equality, growth rate, risk attitudes, and dissatisfaction. Two of the models use the measures calculated with adjusted capabilities, while the other uses measures calculated with internal capabilities. We control for possible misclassification of rising states by estimating one model that includes the interaction of the sides' risk attitudes with the dummy variable for the cases where the stronger side is growing.

Our hypotheses are that equality, dissatisfaction, and the rising state's risk attitude should have positive significant coefficients, the declining state's risk attitude should have a negative significant coefficient, and transitions and growth rates should have insignificant coefficients.

The first model tests these hypotheses using adjusted capabilities and includes alliance transition, alliance equality, the interaction of alliance equality and alliance growth rate, dissatisfaction, and the rising state's and declining state's risk attitudes. We use the interaction of growth rate and equality to capture Organski's notion that growth rates are most dangerous when the sides are relatively equal in capabilities (Organski 1968, 372–73; Organski and Kugler 1980, 28).[14] As can be seen in Table 3, the probability of war increases with rises in alliance equality,[15] dissatisfaction, and the rising state's risk attitude and declines in the declining state's risk attitude. Alliance transitions and the interaction of alliance equality and alliance growth rate have no discernable effect on the probability of war. The sign and significance of all the coefficients are as the model predicts.

The second model tests the stability of the results against the possible misclassification of rising states. It includes interactions between a dummy variable for the cases where the stronger power is growing and the risk variables. The hypotheses remain the same. The results in Table 4 are slightly weaker than those in Table 3. Alliance equality and the declining state's risk attitude have significant coefficients in the anticipated direction. Neither alliance transition nor the interaction of alliance equality and alliance growth rate have significant

[14]This procedure matches Organski and Kugler's (1980, 55) test. Analyses that entered alliance growth rate alone produced a less significant coefficient for alliance growth rate and a more significant coefficient for alliance equality than those reported in Table 3.

[15]Bueno de Mesquita and Lalman (1992) also find that roughly equal capabilities make war more likely.

Table 3. Results of the Basic Model

Independent Variables	Logit Analysis Results
Intercept	−3.00
Alliance transition	0.11
(SE)	(0.68)
(prob)	(0.433)
Alliance equality	2.88*
(SE)	(1.51)
(prob)	(0.028)
Alliance equality × alliance growth rate	0.59
(SE)	(0.45)
(prob)	(0.092)
Dissatisfaction	2.75*
(SE)	(1.55)
(prob)	(0.039)
Rising state's risk attitude	1.55*
(SE)	(0.92)
(prob)	(0.048)
Declining state's risk attitude	−2.27*
(SE)	(1.05)
(prob)	(0.016)

Note: −2 × Log-likelihood ratio = 18.56.

Significance (chi-squared with six degrees of freedom) = .005.

Percentage of cases classified correctly = 73%.

*Significant at the 95% confidence level, one-tailed test. All significance probabilities are based on one-tailed tests of hypotheses derived from the model.

coefficients. But the coefficients for dissatisfaction and the rising state's risk attitude edge below the .05 significance level, although both retain the predicted sign and are quite close to statistical significance at the .05 level.

The third analysis replicates the first, using internal capabilities instead of adjusted capabilities. We test transition, equality, the interaction of equality and growth rate, dissatisfaction, and the sides' risk attitudes. Table 5 presents the results. Although dissatisfaction and the declining state's risk attitude remain significant with the sign predicted by the model, none of the other variables are statistically significant.

What conclusions can be drawn from the statistical analysis? First, the analyses support our model. Risk-acceptant and dissatisfied rising states are more willing to use force to challenge the status quo. Risk-averse declining states are more willing to fight to forestall change. Equality of capabilities makes both

Table 4. Results of the Basic Model with Control for Misclassified Rising States Added

Independent Variables	Logit Analysis Results
Intercept	−2.81
Alliance transition	0.24
(SE)	(0.66)
(prob)	(0.362)
Alliance equality	2.45*
(SE)	(1.48)
(prob)	(0.048)
Alliance equality × alliance growth rate	0.67
(SE)	(0.75)
(prob)	(0.185)
Dissatisfaction	2.36
(SE)	(1.52)
(prob)	(0.059)
Rising state's risk attitude	1.37
(SE)	(1.15)
(prob)	(0.118)
Declining state's risk attitude	−2.84*
(SE)	(1.38)
(prob)	(0.020)
Stronger power growing × rising state's risk attitude	0.79
(SE)	(1.62)
(prob)	(0.312)
Stronger power growing × declining state's risk attitude	1.50
(SE)	(1.96)
(prob)	(0.222)

Note: $-2 \times$ log-likelihood ratio = 18.76.

Significance (chi-squared with eight degrees of freedom) = .016.

Percentage of cases classified correctly = 75%.

*Significant at the 95% confidence level, one-tailed test. All significance probabilities are based on one-tailed tests of hypotheses derived from the model.

Table 5. Results of the Model Using Internal Capabilities

Independent Variables	Logit Analysis Results
Intercept	−1.70
Transition	0.89
(SE)	(0.86)
(prob)	(0.151)
Equality	0.65
(SE)	(1.29)
(prob)	(0.308)
Equality × growth rate	0.62
(SE)	(0.68)
(prob)	(0.183)
Dissatisfaction	2.78*
(SE)	(1.51)
(prob)	(0.033)
Rising state's risk attitude	0.35
(SE)	(0.81)
(prob)	(0.333)
Declining state's risk attitude	−1.75*
(SE)	(1.00)
(prob)	(0.040)

Note: −2 × log-likelihood ratio = 14.81.

Significance (chi-squared with six degrees of freedom) = .022.

Percentage of cases classified correctly = 75%.

*Significant at the 95% confidence level, one-tailed test. All significance probabilities are based on one-tailed tests of hypotheses derived from the model.

sides willing to go to war. These results are robust against simple changes in the operationalization of the variables and specification of the logit models.[16]

Second, that support is mixed for some hypotheses. The coefficients for dissatisfaction and the rising state's risk attitude are not statistically significant at the .05 level in the second model.[17] These variables are often significant at the .05 level and have the sign predicted by the model across replications run to check the robustness of the results.

[16]The two alternative measures of growth rate discussed in note 12 and the lack of interaction between the measures of growth rate and equality were tested.

[17]The bias in the risk scores discussed in note 13 may explain the insignificance of these coefficients in the second model. The risk scores for dissatisfied challengers are biased downward. This bias could reduce the strength of the coefficients for both variables.

Third, adjusted capabilities are necessary to understand the dynamics of power transitions. The third model fails to capture the variables well. The measures constructed with internal capabilities fail to produce significant results in the alternative specifications. Power transitions do not occur in a vacuum apart from the alliances the sides form.

How well does power transition theory hold up in the light of the evidence presented here?[18] Recall Table 1. Our evidence supports Organski's contentions that rough equality of the sides and more dissatisfied rising states increase the chance of war. His other hypotheses do not fare as well. How fast the rising state catches up to the declining state has no statistically discernable effect. The claim that alliances are irrelevant to the initiation of a power transition war is wrong.[19] Transitions themselves have no effect on the probability of war. Similarly, the evidence supports our hypotheses about the effects of risk attitudes over those of Kugler and Zagare (1990). We agree with them that risk-acceptant rising states increase the chance of war, and the evidence supports that conclusion. We contend that risk-averse declining states increase the chance of war, while Kugler and Zagare argue the opposite. The evidence clearly supports our hypothesis. Our evidence leads us to believe that our model of war choices during shifts in power builds on Organski's power transition theory. Where our model agrees with power transition theory, both are correct. Where they disagree, the evidence supports our model.

Conclusion and Discussion

The argument and evidence presented here suggests a broad rethinking of the origin of major wars. Many explanations have been proposed for the recurrence of these wars (Gilpin 1981; Kugler and Organski 1989; Modelski 1983; Organski 1968, 299–338; Organski and Kugler 1980, 1–63; Rotberg and Raab 1988). These explanations generically point to power transitions as the driving element in the origin of major wars. Growth of the capabilities of dissatisfied states increases their ability to push demands for change in the international order. Such demands accumulate over time until the dissatisfied state approaches equality with the state defending the status quo. The accumulated weight of the dissatisfied's demands then triggers a massive war that relieves the accumulated grievance.

[18]Organski (1968) would reject the use of larger number of cases that we employ in our test. He sees power transition theory as relevant only to transitions between the most powerful state and its challengers.

[19]Organski is ambiguous about the role of alliances in power transitions. In Organski (1968), he consistently refers to power comparisons between the dominant state and its allies and the challenger and its allies. In Organski and Kugler (1980, 26), they argue that alliances are irrelevant to power transitions. But as they admit later, "Our tests clearly find alliances to be an important factor in the initiation of major conflict in the central system" (54).

But states should press demands for change whenever they expect to gain from such demands (Morrow 1988, 90–95). A system of rational actors should equilibrate the system over time and eliminate accumulated demands for change. Given that shifts in capabilities are anticipated, demands for change are granted as the dissatisfied rise in power. Grievances cannot accumulate to drive a major war.

Our argument supports this criticism of these theories. Power transitions are just one type of power shift. Predictable shifts in the expected outcome should have the same effect on demands for change whether those shifts move the rising state to 70%, 100% (i.e., equality), or 130% of the declining state's capabilities. In our model, shifts in the expected outcome do not provide a dynamic motivation for war, but the different evaluation of the changing risks of war drives our results.

According to the model, power shift wars—and so power transition wars—are more likely as the expected costs of war decrease. If large accumulated grievances drive big wars, the sides should anticipate the fact and not go to war from the fear of its consequences. This point can be put more simply: *no state initiates war if it expects the war to be long and bloody* (Huth 1988, 74). Power transitions therefore cannot be the cause of major wars. Grievances should not accumulate as nations rise and fall in power. If they do, the anticipation of the long war that would result should suffice to deter that war.

But then why do big wars occur? Big wars are also general wars. No state starts a war expecting to fight a long and bloody conflict, but reality does not always match expectations. The intervention of third parties unpredictably lengthens and intensifies wars. Blainey (1973, 196–97) points out four reasons why general wars tend to be long wars: (1) the distribution of capabilities is more even than in bilateral wars, increasing the likelihood of a military stalemate; (2) general wars produce fighting on multiple fronts, making it unlikely that one side will win on all fronts; (3) the members of a side may find it difficult to agree on a settlement acceptable to all, complicating the negotiations between the sides with those among the members of each coalition; and (4) general wars remove the possibility that a third party can bring it to an end by threatening to intervene. Historically, big wars have begun as small wars that expanded through the intervention of major powers. The Thirty Years' War began with the Bohemian revolt against Austria; World War I started with Austria's declaration of war on Serbia; and World War II began as the German-Polish War.

A set of issues that gives all great powers motivation to intervene is necessary for a general war. Either one issue is so important that all powers see a need to intervene or a set of linked issues draws the powers in one by one as they see a chance to resolve a particular issue in their favor. The wave of liberalism carried by the French Revolution is an example of the former, and the set of territorial disputes before World War I is an example of the latter.[20] Without such issues, few major powers can be drawn into a war because they see no need to intervene.

But these wars do not start as big wars. They expand once they have begun. If the sides anticipated that these wars would expand into big wars with systemic consequences, they would not go to war in the first place. Power transitions serve as the sparks that start big wars. Power transitions precede big wars not because they cause them but rather because they cause the small wars that trigger big wars in the right circumstances.[21]

Alliances and the interests that motivate them also play a critical role in understanding big wars. Big wars require a set of linked issues that draw in all the major powers. Such issues also produce networks of alliances among the major powers. Our statistical analysis shows that support from allies must be included in the calculation of a nation's capabilities. These alliances complicate the question of judging power transitions. Because declining powers are likely to form alliances to bolster their capabilities, actual transitions may occur after the rising state has passed the declining state in internal capabilities. But the allies they choose are critical in determining whether a war expands to encompass all powers. To understand big wars, we need to understand not only the dynamics of relative power over time but also the interests that drive nations into conflict.

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APPENDIX

This appendix presents the analysis of inequality (6) to show when the rising state is willing to fight. The rising state is willing to fight when

$$0 \geqslant 2At^2 + t(B - 2A) + A(1 - t_{crit}^2) - Bt_{crit} + C, \tag{A.1}$$

where $A = \dfrac{g(rRS)}{4(rRS + 1)(rRS + 2)}$ and $B = \dfrac{1}{rRS + 1} - SQ^{rRS}$.

$A > 0$. $B > 0$ unless $SQ \geq (1/(rRS + 1))^{1/rRS}$; the latter can occur only when $rRS < 1/2$ and SQ is close to 1/2. For now, we will assume that $B > 0$. Our results then do not hold for cases with risk-averse rising states that are generally satisfied. The partial derivatives of A and B are as follows:

[20]This observation parallels parts of Midlarsky's (1988, 131–47) distinction between structural and mobilization wars. His analysis of patterns of militarized disputes in the nineteenth and twentieth centuries (1988, 79–91) supports our notion that linked issues are necessary for big wars.

[21]We accept the position of Bueno de Mesquita (1990) that all wars probably can be and should be explained by one theory, and we reject the position of Midlarsky (1990) that separate theories of big and small wars are necessary. Further, we contend that the rational choice approach to international conflict is such a unifying theory. This paper explains how power shifts can lead to the small wars that trigger big wars, and other papers (Altfeld and Bueno de Mesquita 1979; C. H. Kim 1991) explain why some small wars expand into big wars.

$$\frac{\partial A}{\partial rRS} = \frac{g(2 - rRS^2)}{4(rRS + 1)^2 (rRS + 2)^2} > 0 \quad \text{unless} \quad rRS > \sqrt{2}$$

$$\frac{\partial A}{\partial g} = \frac{rRS}{4(rRS + 1)(rRS + 2)} > 0$$

$$\frac{\partial B}{\partial rRS} = \frac{-1}{(rRS + 1)^2} - (\ln SQ)SQ^{rRS}$$

$$\frac{\partial B}{\partial SQ} = -(rRS)SQ^{rRS-1} < 0.$$

The term $\partial B/\partial rRS$ is positive for some values and negative for others.

Equation (A.2) specifies the two roots of the right-hand side of (A.1), henceforth abbreviated as *RHS*.

$$t = 1/2 - \frac{B}{4A} \pm \frac{1}{4A}\sqrt{B^2 - 4AB(1 - 2t_{crit}) - 4A^2(1 - 2t_{crit}^2) - 8AC}. \quad \text{(A.2)}$$

The *RS* is willing to go to war whenever both of these roots are real and less than t_{crit}. First, the roots are real when

$$B^2 - 4AB(1 - 2t_{crit}) - 4A^2(1 - 2t_{crit}^2) - 8AC \geq 0. \quad \text{(A.3)}$$

The partials of this determinant are as follows:

$$\frac{\partial Det}{\partial A} = -4B(1 - 2t_{crit}) - 8A(1 - 2t_{crit}^2) - 8C$$

$$\frac{\partial Det}{\partial B} = 2B - 4A(1 - 2t_{crit})$$

$$\frac{\partial Det}{\partial C} = -8A < 0.$$

The expressions $\partial Det/\partial g$ and $\partial Det/\partial rRS$ cannot be signed because $\partial Det/\partial A$ and $\partial Det/\partial B$ cannot be signed in general. Numerical calculations of the determinant over reasonable ranges of the variables ($.5 < rRS < 1.85$, $-.2 < t_{crit} < .9$, $.5 < g < 1.5$, $.15 < SQ < .45$, and $.01 < C < .1$) reveal that the determinant is more likely to be positive as *rRS* and t_{crit} increase and as *g*, *SQ*, and *C* decrease.

Second, the roots must be less than t_{crit} for war to be possible. The *RHS* is a parabola that opens upward. When $t = t_{crit}$, $RHS > 0$. Then t_{crit} cannot fall in the interval between the roots and must be larger than the two roots for *RS* to be willing to go to war. This also implies that $\partial RHS/\partial t|_{t=t_{crit}} > 0$ as $RHS(t)$ is an upward parabola with t_{crit} greater than the two real roots. Calculating this inequality, we have the following:

$$\left.\frac{\partial RHS}{\partial t}\right|_{t=t_{crit}} = 4At_{crit} + B - 2A > 0$$
$$t_{crit} > 1/2 - B/4A. \quad \text{(A.4)}$$

The partials of the right-hand side of (A.4), abbreviated *4HS*, are as follows:

$$\frac{\partial 4HS}{\partial g} = \left(\frac{B}{4A^2}\right)\left(\frac{\partial A}{\partial g}\right) > 0$$

$$\frac{\partial 4HS}{\partial SQ} = \left(-\frac{1}{4A}\right)\left(\frac{\partial B}{\partial SQ}\right) < 0$$

$$\frac{\partial 4HS}{\partial rRS} = \left(-\frac{1}{4A}\right)\left(\frac{\partial B}{\partial rRS}\right) + \left(\frac{B}{4A^2}\right)\left(\frac{\partial A}{\partial rRS}\right)$$

$$= \frac{1}{4A}\left[\ln(SQ)SQ^{rRS} + \frac{2 - 2SQ^{rRS} + r^2SQ^{rRS}}{rRS(rRS + 1)\,(rRS + 2)}\right].$$

The expression $\partial 4HS/\partial rRS$ cannot be signed in general; the first part is negative, and the second, positive. Numerical calculations of its value for typical ranges of the variables ($.5 < rRS < 1.6$ and $.1 < SQ < .45$) reveal that $\partial 4HS/\partial rRS < 0$ except when SQ is less than .2. This threshold of dissatisfaction where the sign reverses increases with rRS.

Collecting the two parts of the argument, (A.1) is more likely to be true as rRS increases, SQ decreases, C decreases, and g decreases. These results hold across typical values of the variable. They do not hold when $SQ > (1/(rRS + 1))^{1/rS}$ or $SQ < .2$.

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