The Balance of Power: Formal Perfection and Practical Flaws*

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A game-theoretic model is used to show that the balance-of-power mechanism has much greater formal power than hitherto understood. Under the strong assumption that all threatened countries must be able to function as crucial coalition partners in deterring any threat, all members of minimum winning coalitions are guaranteed not to lose any resources. Under the traditional, weaker assumption that some coalition must be available to deter any threat, even countries that are not members of minimum winning coalitions are guaranteed against losing any resources. These formal results are significant in two ways. First, they make it possible to reconcile apparently contradictory views in the literature, and to offer a satisfying intuitive interpretation of the balance-of-power mechanism. Second, they point to a variety of factors – operating both separately and interactively – that may cause the balance-of-power mechanism to fail. Examples are uncertainty combined with risk-loving preferences, conflict-averse preferences, offensive technological advantages, economic growth, and technological and political rigidities in the formation of alliances and rivalries. It is argued that efforts to test balance-of-power theory should focus on assessing the relative importance of such factors.

Introduction

The balance-of-power mechanism is the process by which any threat by one or more countries against one or more other countries is countered by a third, possibly overlapping, set of countries. There is a long tradition of viewing the balance-of-power mechanism as the main bulwark against the forcible redistribution of resources in the international system. (Such redistributions may occur through wars, or through capitulations to credible threats of war.) However, there has been little agreement on the mechanism's effectiveness, or on how and why it is most likely to fail. This article uses a game-theoretic model of the balance of power to show that, formally at least, the mechanism is far more powerful than is commonly realized. In particular, the balance of power can prevent any redistribution of resources whatsoever among 'great powers', defined broadly as countries that are members of at least one minimum winning coalition (MWC).

Moreover, under the traditional assumption that the balance-of-power mechanism works through the decentralized responses of any relevant country or countries, the model implies that even countries that are not members of any MWC are guaranteed against any loss of resources.

* An Addendum to this article is available at http://www.uwm.edu/Dept/Polsci/faculty/horowitz.html. It describes how the present model differs from that of Niou & Ordeshook (1986) and Niou, Ordeshook & Rose (1989).

1 A minimum winning coalition has over half the resources in the system, but would have half or less of the resources if any one member country were to withdraw.
These strong resource stability results may appear to amplify the empirical riddle. After all, the balance-of-power mechanism has often failed to deter war and other means of redistributing resources. However, it is argued that a fuller appreciation of the mechanism’s formal power helps to produce a better understanding of its practical failures. The formal model implies a two-pronged approach to empirical tests of the balance of power. First, it implies that, in systems with more concentrated power, there should be fewer wars involving more great powers. Second, there is a whole range of ways in which relaxing the model’s assumptions will tend to produce failures of the balance-of-power mechanism. Since no particular subset of these possibilities is logically to be privileged over the others, and since they often interact, it is natural to focus on testing their relative importance in explaining failures of the balance-of-power mechanism in a given historical period. On the other hand, unless it is argued that the number of great powers, and the distribution of power between them, has no effect on the probability of particular wars breaking out, it is not easy to see how the balance-of-power logic as a whole can be tested and falsified. What can be tested and falsified are particular views about what conditions make it more or less likely for the mechanism to deter war and the redistribution of resources.

A brief survey of some of the literature’s classics appears to show a bewildering variety of views. Waltz (1979: 168–170) argues that the balance-of-power mechanism is most effective in ‘bipolar’ systems, with their heavily concentrated power. This is because the two largest states can rely primarily on their own internal efforts to deter each other. On the other hand, ‘multipolar’ systems of three or more great powers often have to rely on alliances as well as their own arms, and these more often prove unreliable. Here the biggest source of balance-of-power failure is uncertainty about the reliability of alliance commitments. On the other hand, Claude (1962: 42, 54–57, 88–93; see also Organski, 1958: 293–295) views systems with only two great powers as the most unstable. Take the best-case scenario, where the two are relatively evenly matched – so that neither can impose its will with confidence. Here there is a high probability that one or both will be highly tolerant of risk, and seize the opportunity to win total victory even at the risk of total defeat. Wagner (1994: 603) concurs with Claude about two-power systems. Wagner also argues that multi-power systems are most stable when one country (or some reliable coalition of two or more countries) comes uncomfortably close to possessing half the resources in the system. This most reliably calls forth a credible counter-coalition. Finally, Niou & Ordeshook (1986) argue that the balance-of-power mechanism protects the survival of all great powers, but does not protect any of the great powers against more limited resource losses to other great powers. As long as there are more than two countries in the system, and no one country starts with enough power to dominate the system, this logic applies to systems with two great powers as well as systems with more than two great powers. This article seeks to clarify these varying positions by showing that the balance of model mechanism has much stronger logical implications than has been realized, and by itemizing and analyzing a list of factors that would logically produce failures of the balance-of-power mechanism. The analysis shows that, once assumptions are more explicitly spelled out, there is in fact less disagreement in the literature than meets the eye.

The following section advances a game-theoretic model of the balance of power. It is shown that the process of allowing stylized countries to deter threats in pursuit of their own predatory interests produces complete resource stability. The third section considers
some interpretive issues raised by the model, and considers a variety of ways in which modifying the assumptions may lead to failure of the balance-of-power mechanism. The fourth section attempts to derive implications for empirical testing.

A Model of the Balance of Power

The model assumes a zero-sum world. All countries maximize relative power subject to a survival constraint. Countries, or coalitions of countries, propose redistributions of the resources of other countries having fewer resources, and these redistributions are implemented unless some other coalition proposes a redistribution that dominates the preceding proposal. The assumptions and relevant definitions are as follows.

Assumption 1: The total amount of resources in the system, R, is constant, divisible, and transferable.

Assumption 2: Any coalition $C^a$, made up of one or more countries $i, j, k, \ldots$, with more resources than another coalition $C^b$, can propose that $C^b$'s resources be redistributed by seizure. Any coalition $C^a$ can also propose, either separately or along with a redistribution of $C^b$'s resources, that some resources of one or more of its own members be redistributed by transfer.

Assumption 3: Such proposed redistributions are implemented unless there is some other coalition $C^c$, which is able to block $C^b$, proposing another redistribution. $C^c$ can block $C^b$ if it has either equal or greater resources. $C^c$ may acquire sufficient resources to block $C^b$ by attracting away one or more members of $C^b$.

Assumption 4: Countries participate in coalitions proposing to redistribute resources if and only if the proposed redistribution leaves them better off with certainty than if they did not participate. They are better off either if they are left with more resources, or if they are left with the same resources but with a larger share obtained by transfer as opposed to seizure from other countries. Countries are better off with certainty if they can be sure that a proposed redistribution making them better off will not make them worse off later in the game.

Assumption 5: If all of a country's resources are eliminated as a result of a redistribution, then that country ceases to exist.

Assumption 6: Each play of the game consists of a sequence of proposed redistributions, with proposals being succeeded by other, dominating proposals, until some undominated proposal is made and then implemented. ('Undominated' is further defined in assumption 8 below.) There is no imposed limit on the number of proposals in each play of the game, or on the number of plays in a game.

Assumption 7: There is complete information about the rules of the game and about the preferences and resource endowments of all the countries.

Definition 1: A system of countries with a given resource distribution at the start of one of the plays of the game is system-stable if no country can be eliminated through proposed redistributions that are implemented.

Definition 2: A system of countries with a given resource distribution at the start of one of the plays of the game is resource-stable if no country's resource endowment can be changed through proposed redistributions that are implemented.

Definition 3: A proposed redistribution by $C^a$ at the expense of $C^b$ is a threat if (a) it is the first proposal in a given play of the game, (b) all members of $C^a$ are to end up with more resources than they start with at the beginning of the play, (c) all members of $C^b$
are to end up with fewer resources than they start with at the beginning of the play, and (d) \( C^i \) has more resources than \( C^j \).

Definition 4: A proposed redistribution by \( C^i \) is a counterthreat if (a) it follows a threat or another counterthreat in a given play of the game, (b) all members of \( C^i \) end up better off than they would have been if the previous threat or counterthreat was implemented, (c) \( C^i \) has the same or more resources than the coalition making the previous threat or counterthreat, and (d) one of the following:

- the proposal exclusively involves seizing resources from \( C^d \),
- the proposal exclusively involves transferring resources from one or more members of \( C^i \) to one or more other members of \( C^i \) (the latter may or may not be members of the coalition making the previous threat or counterthreat), or
- the proposal involves a combination of seizing resources from \( C^d \) and transferring resources from one or more members of \( C^i \) to one or more other members of \( C^i \).

Definition 5: A counterthreat by \( C^i \) is initiator-dependent if the proposing country \( i \) has enough resources to block the counterthreat by withdrawing or changing sides, i.e.

- if \( C^i \) without country \( i \) does not have the same or more resources than \( C^d \), or
- if \( C^i \) without country \( i \) does not have more resources than country \( i \) combined with \( C^d \), or
- if country \( i \) is necessary to make a proposed resource transfer, or
- if country \( i \) is necessary to accomplish a proposed seizure from \( C^d \) and a proposed transfer simultaneously.

Two alternate versions of Assumption 8 will be discussed. In the first and strongest version, *every country targeted* for resource seizure must be able to mount an initiator-dependent counterthreat to prevent the previous threat or counterthreat from being implemented. In the second and weaker version, if *any country not participating in the previous threat or counterthreat* is able to mount an initiator-dependent counterthreat, that is sufficient to prevent the previous threat or counterthreat from being implemented. Note that a counterthreat involving a pure transfer is necessarily implemented under the first version, but not under the second.

Assumption 8.1: A threat or counterthreat is undominated and hence implemented unless the first country responding, which is randomly selected from among the countries targeted for resource seizures, can propose an initiator-dependent counterthreat.

Assumption 8.2: A threat or counterthreat is undominated and hence implemented unless *all countries*, which are randomly selected in turn from among the countries not participating in the previous threat or counterthreat, cannot propose an initiator-dependent counterthreat.

Theorem: Suppose that Assumption 8.1 holds. Suppose that all countries are members of at least one minimum winning coalition, and that all countries possess less than half the resources in the system. Then all countries have initiator-dependent counterthreats against all threats, and therefore are guaranteed not to lose any resources.

Proof: See the Appendix.

To briefly sketch the method of proof, there are two key requirements in showing that a given country \( i \) has counterthreats against any threat. First, it must be shown that, for all possible threatening coalitions, country \( i \) can construct a coalition that is at least as large as the threatening coalition, and that makes *all* countries in the new counterthreatening coalition better off than they were under the previous threat or counterthreat. A coalition at
least as large can be constructed using other countries attacked under the previous threat or counterthreat, or countries that were neutral (neither attacked nor attacking), or countries that were attacking, or some combination of these. Countries can be made better off either by being offered more resources, or offered the same amount of resources with a higher share achieved by transfer. And such improvements must not be achieved at the cost of endangering the countries' survival later on in the game.

Second, all of country i's counterthreats must be initiator-dependent. That is, it must not be possible for the coalition members other than i to make the same counterthreats if i actively opposes them. This is the same as saying that counterthreats fail if i switches sides and joins the targeted countries.

Counterthreats can take three different forms: (1) a new seizure, (2) a resource transfer, or (3) a hybrid consisting of both a seizure and a resource transfer. Under Assumption 8.1, a simple resource transfer cannot be countered. Therefore, simple resource transfers can never be used in a proof of resource stability under this assumption. Resource stability is proven by showing that all threats can be met with counterthreats that are either seizures or hybrid seizure-transfers, and that all such counterthreats can be met with another set of counterthreats that are either seizures or hybrid seizure-transfers, and so on. In that case, no threat or counterthreat is ever implemented, and the initial distribution of resources remains unchanged.

It follows immediately from the theorem that, under the weaker Assumption 8.2, all members of minimum winning coalitions are guaranteed resource stability. For some members of minimum winning coalitions necessarily benefit less from any proposed way of dismembering these small fry. But the proof in the Appendix shows that these members have counterthreats in which they benefit more, and so on. Thus, under Assumption 8.2, as long as no country begins with more than half the resources, the resource stability result holds for all countries. In the Appendix, it is also shown that, under 8.2, hybrid seizure-transfer counterthreats only need to be used in one situation: to counter a 'marriage' threat, a threat by two countries to divide the entire system evenly between them.3

Interpretation, Generalizations, and Limitations

The formal strength of the balance-of-power mechanism far exceeds its historical ability to deter countries from redistributing resources, usually by launching wars. The question is why, and whether plausibly relaxing some assumptions predicts a pattern of balance-of-power failures that appears empirically accurate. Promising areas for modifying assumptions include preferences over resource gains and losses, complete information, static resource endowments, changes in military technology, and flexibility of alliances and rivalries. It will be argued that none of these modifications changes the basic logic of the balance-of-power mechanism. However, all of them point to ways in which

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3 In the Addendum available on the author's web site, there is a brief discussion of how the model here differs from that of Niou & Ordeshook (1986). There it is shown that resource stability also follows under their assumptions, including the more stringent requirement that counterthreats be 'viable'. (Counterthreats are viable only if they cannot be conducted without country i. This is a stronger assumption than initiator-dependence, which allows non-viable counterthreats where i can block them with active opposition.) This is an advance over their results, which show that countries are guaranteed survival (system stability) but not resource stability.
necessary conditions for an operative balance-of-power mechanism can fail. This occurs either when power in effect becomes too concentrated, or when it is perceived as having become too concentrated.

To begin, it is helpful to discuss some basic interpretive issues. How is the balance-of-power mechanism to be understood intuitively? To what extent does its logical purity conceal important behavioral discontinuities and paradoxes? First, it is worth emphasizing what, according to the model, the balance-of-power mechanism is not. It is not a way of making rival coalitions evenly matched. As discussed below, in a world of uncertainty and of variation in risk preferences, more evenly matched means less, rather than more, stable. The balance-of-power mechanism is a way of adapting coalition patterns so that members of an initial threatening coalition can be overawed or seduced, and the counterthreatening coalition members overawed or seduced, and so on. Thus it is a way of eliminating the superiority of would-be threatening coalitions. Equality is the weakest possible form of eliminating this superiority.

In the world of the simple balance-of-power model, the system is ‘frozen’ if some country has exactly half the resources. No country can try to change anything, because any momentary loss of vigilance can allow the near-hegemon to gain a slight additional advantage. On the other hand, if some country has close to, but still under half, the resources, all possibilities can be considered. Countries are simply careful with any country having nearly half the resources, just as they are about accepting proposals that would bring other countries up close to half the resources. Of course, it is unrealistic that a real-world system could be literally ‘frozen’ when a country gains half the resources.

Above all, this is because countries would not know exactly when they have half the resources, or whether what they do have would be enough to defeat the rest with certainty (see below). It would be more realistic to say that the system would be in crisis as a country neared possession of half the resources for fear that the near-hegemonic country would become hegemonic. Such a situation would be so unpredictable and dangerous that countries would seek to avoid it to begin with. But this point still allows us to salvage much of the logic of the simplified model. Countries in the real world would seek to block even another country’s approach towards possessing half the system. There is some cushion short of possessing half the resources that would allow a given country to feel more secure about ‘dealing’ with other, very powerful countries. It is this discontinuity that the model captures, although it is unrealistic in locating the dividing line right at half the resources, and in deducing that the transition between the two sets of conditions is instantaneous and similar for all countries.

In this context, an important behavioral paradox arises in connection with the resource stability result. Consider the basic assumption on preferences that all countries seek to maximize relative resource endowments subject to a survival constraint. Such preferences do not sit well with the resource stability result. Countries are supposed to care above all for gaining more power. At the same time, they are expected to give up proposed redistributions that promise close to the maximum gains possible, just because another one comes along that offers slightly more – whether a small additional increment.

5 Thus, proposals to bring a given country up to half the system’s resources are not credible. If it is assumed that a proposed redistribution can be stopped and redirected at any point by proposing threats and counterthreats taking that point as a reference (see Smith, 1998; Wagner, 1986), a similar objection follows immediately. Even if a ‘system-freezing’ proposal is not initially countered, it cannot be fully implemented. As the country to reach half the resources gets close, both it and its ally or allies have an incentive to violate the agreement before the other does.
of resources or a small increment transferred rather than seized. They are supposed to do this even though they know that such behavior will leave them with no gains whatsoever. Rather than allow this frustrating process to continue indefinitely, won't countries sooner or later jump at some relatively good offer, knowing that they can worry about getting even more once they have digested this first round of gains? This objection is a fundamental one, but it is also incomplete at this level of generality. How close does the offer have to come to the maximum attainable before it gets ‘good enough’? Which of the offers above this threshold will be chosen? If there is also some uncertainty about countries’ resources or the outcome of fighting (see below), the maximum attainable is also highly uncertain – and is probably well below half the system’s resources. Thus, while it is plausible that impatience with the predictable resource stability consequences of the balance-of-power mechanism will produce periodic failures, there is still a need to predict when and how such failures are most likely to occur.

Other issues arise in connection with the assumed threat–counterthreat protocol for redistributing resources. The balance-of-power logic operates just as perfectly once a conflict begins as it does before a conflict starts. Hence, I can invade my weaker neighbor, and then utilize counterthreats to deter other countries from intervening to stop the conquest. All countries, either alone or in coalitions, can act in this manner. A country considering a unilateral attack has to worry about other countries acting unilaterally to deliver on potential counterthreats, ignoring the threat–counterthreat protocol in the same way. This should operate as a kind of ‘credibility constraint’ on counterthreats. A counterthreat may exist in principle, but if it is not likely to be used in practice, it will not effectively deter countries from pursuing threats. Unilateral attacks should be deterred by the potential for unilateral responses, although such deterrence is not as certain if the unilateral attack respects the hazy ‘comfort zone’ short of half the resources. A related point is that the model’s assumption that threats or counterthreats are pursued serially and exclusively is not realistic. Hence the reaction to a threat could be to make a distinct, disjoint threat, rather than a counterthreat. But this is the same as a larger, joint threat, and can be countered in the same way.

To summarize the intuitive discussion of the model, the balance-of-power mechanism operates by overawing or seducing members of all threatening coalitions. This is less certain once a country comes too close to hegemony. Such a concentration of power threatens the survival of all other countries simultaneously, while making it more difficult to reliably deter a bid for hegemony. So, where such potentially hegemonic threats do not already exist, the mechanism should be more reliable in preventing them from developing than in preventing other kinds of redistributions (Wagner, 1994: 303). On the other hand, some aggressive countries are not likely to be deterred indefinitely, especially where some threats seem less likely to be effectively resisted than others. So, the question becomes, where and in what specific forms are such failures most likely?

Now, consider some specific ways of modifying the model’s assumptions. The following is meant to be a suggestive rather than an exhaustive discussion of these possibilities. Suppose first that some countries are ruled by regimes – whether democracies or inwardly oriented authoritarian regimes – that care only about defense.6 The model can readily incorporate this possibility. It simply means that such defensively oriented countries do not participate in the game unless

6 Presumably this is primarily because they assess the costs of war more highly – whether because they are accountable to agents that bear these costs more heavily, or because they think the costs increase the probability of being driven from power. See Morrow (1993); Rosecrance (1992); Russett & Maoz (1993).
they are threatened. If they are threatened and are members of at least one MWC, they can respond with initiator-dependent counterthreats. If they are not threatened, then the rest of the system becomes a self-contained subsystem. As long as no country has over half the subsystem resources, all countries that are members of subsystem MWCs can also respond with initiator-dependent counterthreats. If some country has more than half the subsystem resources, that country can swallow the rest of the subsystem as long as the result is not to give it more than half the resources in the larger system.

Other modifications can be similarly accommodated. For example, suppose countries' resources are assumed to be growing or contracting at various rates as a result of economic activity. This amendment has the additional benefit of more systematically integrating the economic costs of war—as a drag on growth rates to be trading off against anticipated gains from war (Hirshleifer, 1991; Powell, 1993, 1999). Here, the difference is that the status quo reference point for evaluating proposed redistributions is constantly changing. In such cases, there is no necessary conflict with the 'power transitions' literature, which focuses on whether great powers' changing relative power makes war more or less likely (e.g. Organski, 1958; Tammen et al., 2000). The implication of the simple model above is that power transitions only produce qualitative changes in the operation of the balance-of-power mechanism when they are projected to take a given great power beyond half the resources in the near future. In that case, the resource stability result of the static resources version of the model implies that all proposed rectifying redistributions could be blocked by others until the fast-growing country is right on the verge of reaching half the resources. Since this could lead to the extinction of all the other countries, it is a far less credible outcome than the static-resources analog in which power-hungry countries consent to remain permanently deprived of gains. In this case, the status quo becomes increasingly intolerable. But it is not easy to predict which of the infinite number of possible rectifying redistributions will be implemented. In practice, no large country has ever been able to maintain sufficiently high growth rates for long enough to make this scenario an impending reality. But it can be argued that such situations have developed in subsystems. For example, fast Russian economic growth before World War I made German and Austrian leaders increasingly desperate in their planning for war with Russia and France (Bridge & Bullen, 1980: 164–179; Kaiser, 1990: 318–325).7

Yet another similar example is changes in military technology that provide an advantage to the offense or the defense (Van Evera, 1984). Suppose the offense has the advantage. This expands the number of feasible threats. Threats by coalitions can still be countered in the same way, by creating a dominating counterthreat. Although there is a lower ceiling on gains that can be offered in proposed redistributions, it is still possible to play indefinitely the game of constructing larger coalitions offering incremental improvements. But there must now be a large initial margin of safety keeping all potentially aggressive countries well short of half the resources—with the size of the margin corresponding to the initial distribution of power and the extent of the offense's advantage. If this margin is too small, the balance-of-power mechanism is liable to fail catastrophically. An advantage of the defense over the offense would have the opposite effect, making it possible to deter threats by some weakly hegemonic countries, and to credibly propose redistributions that bring some country beyond half

7 Why couldn't this situation have been avoided by breaking the prevailing pattern of alignments, or bringing in third parties? Clearly, other assumptions of the model also failed to hold in this example.
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the resources. Here it is easy to see how technological change, for example from a defensive to an offensive advantage or from a smaller to a larger offensive advantage, could undermine the balance of power. This in turn implies that countries are likely to be cautious about assuming an advantage to the defense, or about discounting the possibility of a shift towards greater advantage to the offense.

Now, relax the assumption that resources are completely fungible for military purposes. This assumption is unrealistic for a number of reasons. Different types of military forces – most importantly, land-based and seaborne forces – cannot be used interchangeably for all types of missions. Similarly, variations in distance and (on land) topography mean that given types of military forces cannot be used with equal effectiveness against all potential enemies. Instead of a single resource distribution for purposes of analyzing all possible threats and counterthreats, there are multiple resource distributions corresponding to different sources and directions of military activity. Again, however, unless such technological specificity gives some country more than half the resources in one of the various land and sea subsystems, it does not change the balance-of-power mechanism – although it significantly complicates calculations for making threats and counterthreats.

Consider the assumption that all countries can be allies and rivals of all other countries. This, also, may not be true for a variety of reasons. Countries with similar regime types or cultures may sometimes refuse to consider fighting each other. Similarly, other countries may refuse to ally with each other; for example, due to conflicts over territory that both claim as part of their national heritage. Depending upon the pattern of such rigidities, there may be fewer threats requiring countering – making the system easier to stabilize – or fewer coalitions available to form counterthreats – making it more difficult to stabilize. Such factors are important in accounting for the example given above of Germany and Austria being rigidly opposed to France and Russia. But the basic character of the mechanism is again unchanged. It fails only if some country or rigid coalition acquires over half the resources in the system or relevant subsystem.

Similar changes follow from relaxing the complete information assumption. If there is uncertainty over the outcomes of conflicts between coalitions of given resource endowments, it forces one to make assumptions about countries’ risk preferences (Claude, 1962: 54–57, 88–93; Kim & Morrow, 1992; Powell, 1999). If the outcome of conflict cannot be known with certainty, then even survival cannot plausibly be assured with certainty. Here variations in risk preferences have a big impact. If all countries are risk-averse, the effectiveness of the balance-of-power mechanism is reinforced. It becomes more difficult to mount threats and easier to mount counterthreats, because smaller coalitions have a chance of winning. On the other hand, if some or all countries are risk-loving, it becomes more difficult to deter them with counterthreats, i.e. it becomes necessary for countering coalitions to expand their resource advantages. If relatively large countries have relatively risk-loving leaders, it becomes difficult to avoid war.

Yet another possibility is to allow uncertainty about resource endowments. One way to integrate this would be to assume some rational updating process, whereby initial assessments are altered based upon the outcomes of conflicts or other new information. Even without uncertainty about outcomes of conflicts between coalitions of given resource endowments, this also forces one to make assumptions about risk tolerance. Again, general risk aversion facilitates the balance-of-power mechanism, whereas one or more
risk-loving countries make larger countering advantages necessary to deter conflict.

To summarize, a wide range of model assumptions can be relaxed while retaining the basic model’s logic and the resource stability result. But resource stability can fail if effective initial resource distributions, perceptions of such distributions, or risk preferences are altered. These failures make it likely that wars and/or resource redistributions will occur. For example, effective initial resource distributions can be dramatically altered if one or more sufficiently large defensively oriented countries ‘opt out’ of the system, if some large country sustains relatively rapid economic growth for a sufficiently long time, or if military technology changes to provide a large enough advantage to the offense over the defense. Similar effects can result from networks of rigidities that prevent the balance-of-power mechanism from adapting to changing threats and counterthreats. In this class of cases, the noted types of changes in the system can give one or more countries the power to unilaterally take some or all the resources of one or more other countries. Fearon (1995, 1998) has argued that wars would not actually take place in such cases, because it would pay for the vulnerable countries to yield rather than fight a costly war that all know to be doomed to failure. This is logical, except for cases where the result is so intolerable that the victim, rather than accepting the result ‘lying down’, prefers to preserve some brief period of independence and impose some costs on the predator.

Perceptions of resource distributions can cause failure when they lead one or more countries to believe that their resources are sufficient to unilaterally impose a redistribution – even when their resources may not in reality be sufficient. Here, it is more likely that actual warfare will break out, because it is possible that other countries will have different assessments of the resource distribution.8 If there is uncertainty about the outcome of fighting between coalitions of known resource endowments, and if one or more sufficiently large countries have risk-loving preferences, then again actual warfare is likely to break out. Thus, in the presence of uncertainty, it is plausible that warfare will break out as a prelude to resource redistributions. This is because the outcome of the warfare is not known in advance with certainty, so that countries may end up better off by disputing attempted redistributions.

It should also be noted that the various sources of balance-of-power failure can occur together, often in a mutually reinforcing manner. For example, it may be that, in the presence of uncertainty about both resource endowments and the outcome of fighting between coalitions of given resource endowments, leaders who are risk-loving also commonly exaggerate their countries’ capacities while underestimating those of their opponents. The pre-World War I alignment of Germany and Austria against France and Russia has already been discussed as involving both rigidities impeding the formation of counterthreats and threateningly high growth rates in Russia.

Empirical Testing

The discussion in the previous section has two main types of empirical implications. One has to do with the effects of greater concentration of power. Three basic situations are distinguished. (1) An expansionary-oriented country’s resources approach half of the system, or look as if they might as a result of current expansionary projects: There is likely to be a systemic crisis in which all countries feel increasingly compelled to act. In such situations, the balance-of-power logic, of incrementally improved offers producing indefinitely deferred redistribution plans, is

8 I thank an anonymous referee for emphasizing this distinction.
more likely to fail based on the rival logic that what is now possible is nearly the best or the worst of all possible worlds. This scenario can only be plausibly avoided if near-hegemonic countries have some way of credibly committing to forgo further expansion. (2) No expansionary-oriented country has near half the resources, but one or more is threatening redistributions that bring its resources close to half of the system: Other things being equal, counterthreats are likely to be more credible and effective, because all countries are compelled to respond to protect their survival, and together they possess a significant resource advantage over the main expansionary threat. (3) No expansionary-oriented country has near half the resources, and threats only propose limited redistributions that leave all countries well short of half the resources: Other things being equal, counterthreats are more likely to be challenged by unilateral action combined with counter-counterthreats, because countries essential to counterthreatening coalitions are often not themselves threatened.

There are implications for both numbers and types of conflicts. Systems with highly concentrated power should have more general conflicts, involving all or most of the great powers. Such general conflicts should become more common as aspiring hegemons approach half the system's resources. Systems of more dispersed power should have more local conflicts, involving smaller proportions of great powers. There should be more conflicts in such dispersed systems precisely because it is more likely for conflicts to remain localized, and because multiple conflicts occurring at one time are not necessarily part of a single generalized conflict (Aron, 1973: 128).

A second type of implication is that the rival logic of trying to get something is often likely to undermine the balance-of-power mechanism's logic – the logic of getting nothing because one always insists on trying to get more. Of course, it is not easy to predict when and in what form this rival logic will take hold. Here the most promising approach is to try to estimate the relative importance of a variety of factors that might be expected to facilitate such balance-of-power failures. The factors discussed in the previous section do so by rendering given resource distributions more effectively concentrated and hence unbalanced – whether in reality or merely in the perceptions of one or more countries, whether globally or in some subsystem. In principle, one could code for factors such as risk-loving preferences of great-power leaders, conflict-averse preferences of other great powers, technological innovations that shift the advantage significantly to the offense, and political and technological rigidities in alliance and rivalry formation. All of these factors can be thought of as increasing the concentration of power in the system or in some subsystem. But some of them are more easily measured than others. For example, it is easier to code for the effect of a country being conflict-averse than to decide how risk-loving a giving leader was. Moreover, multiple factors that contribute to failure of the balance-of-power mechanism are typically present, often having an interactive effect that they could not have had acting separately.

These complications are best illustrated with an example. Suppose the dependent variable data point in question is the outbreak of World War II. Suppose that proxies for military power show that the only members of minimum winning coalitions were Britain, France, Germany, Japan, the USA, and the USSR. It can be argued that the USA was conflict-averse, i.e. not likely to enter a war unless attacked, for as long as the consequences were not expected to bring a potentially threatening country like Germany too close to possessing half the resources. One could also make the simplifying assumption that Japan could have little impact outside the Asia-Pacific region once it made the decision not to strike at Soviet Siberia. In this context, Hitler was not
only expansionist but also risk-loving, i.e. bent on attempting expansion even in the face of a high risk of total defeat. Stalin was also expansionist, albeit in a more cautious fashion than Hitler. Thus, he sought to make initial gains while diverting Germany’s main military effort westward. Once Germany was fully engaged in a World War I-style quagmire in France, it would be possible to enter the war at an opportune moment to make further gains. We know in hindsight that uncertainty played a role here, with Stalin seriously underestimating Germany’s relative power. Hitler’s preferences, along with Stalin’s preferences and miscalculations, thus made the Hitler–Stalin Pact possible – foreclosing the possibility of a pre-emptive alliance of Britain, France, and the USSR. But how is this combination of factors to be coded? There was a high concentration of German power, made higher by US isolationism, interacting with an expansionary, risk-loving German regime, a more cautiously expansionary Soviet regime, and a high degree of uncertainty. It could be assumed that there is always a high degree of uncertainty, or in any case that variations in uncertainty are too difficult to try to measure. In that case, the coding would be for a compound concentration term reflecting initial German power, US isolationism, Hitler’s preferences and high risk-tolerance, and Stalin’s preferences. Further complications could be added, but the point is clear. Factors expected to contribute to a failure of the balance-of-power mechanism have to be tested not only individually, but also in plausible interactive forms.

Two final points should be added. The prediction that there should be fewer but more general wars in systems with more concentrated power has to be tested after adjusting for factors that increase the effective concentration of power. Whatever the results indicate about the relative importance of the factors increasing the effective concentration of power, such results cannot necessarily be extrapolated into the future. The features of past international systems often are not representative of present and future systems.

Conclusions

To conclude, refer back to the introductory literature survey. Waltz’s confidence in the greater stability of systems with two great powers is due to his assumption that such great powers are risk-averse. If one or both is not, the balance of power becomes susceptible to failure on a grand scale, as discussed by Claude and Wagner. Wagner concurs with Waltz that alliances may prove to be unreliable. Hence, Wagner argues that multi-power systems are most stable when (1) no power comes close enough to possessing half the resources to make a hegemonic war an appealing gamble; and (2) some power is making a concerted enough effort to get to that point that the other powers feel compelled to reliably assist one another. Hence, there appears to be a large degree of consensus on some factors likely to produce failure of the balance-of-power mechanism. It has been argued above that there are a large number of such factors, often operating interactively, and that which are most important in any given historical period is an empirical question. Given the difficulty of measuring many of the relevant variables, however, it is not an easy empirical question.

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9 It is also possible to attribute this to a change in military technology and tactics, which made possible more rapid and devastating use of highly mobile, tank-led offensives. But this would assume that these changes in military technology were well understood in advance.

10 It cannot be known whether the latter would have deterred Hitler. But it certainly would have significantly increased the probability of doing so, at least in the short run. Thus, Heller & Nekrich (1986: 316–369) argue that Stalin gambled with the USSR’s security in order to pursue territorial gains in Eastern Europe. It could be argued that Stalin did not have a realistic option of alliance with Britain and France, because these countries had shown themselves unreliable in allowing Hitler to ‘swallow’ Czechoslovakia. But Britain and France made repeated public commitments to defend Poland, and backed them with dramatic new military preparations (including peacetime conscription in Britain) (Carr, 1947: 267–278).
Niou & Ordeshook (1986) sought to determine the formal strength of the balance-of-power mechanism. They found that only members of MWCs are invariably expected to survive, and that all countries are expected to experience resource gains or losses. The stronger results derived in this article imply that no members of MWCs should lose resources. Under the slightly weaker but still plausible Assumption 8.2, no countries are expected to lose resources. In principle, this considerably simplifies the process of empirical testing, since all resource redistributions can be considered practical failures of the balance-of-power mechanism.

It is worth making one final theoretical point. Country preferences, over resource gains and risk, are crucial in assessing the stability of any given international system. No effort has been made to try to explain change in such preferences. The constructivist school in international relations theory (e.g. Aron, 1973; Katzenstein, 1996) has emphasized that country preferences are interdependent and endogenously evolving in the process of international interaction. The same has been argued for military technology and tactics (e.g. Dupuy, 1980; Paret, 1986). In principle, it would be desirable to theorize all relevant parameters of the balance-of-power model endogenously. However, it is difficult to do this in a manner that is historically generalizable. This explains — though it does not necessarily excuse — the frequent tendency to take such parameters as given.

Appendix: Resource Stability Proofs

Proof of Resource Stability under Assumption 8.1
Suppose all countries are members of at least one minimum winning coalition (MWC), and that all possess less than half the resources in the system. Distinguish two types of membership in MWCs, based on differences in initial resource distributions. In Case 1, country $i$ can pivot between two MWCs having no other common members, each of which has less than half the system’s resources without $i$. Label the two groups from which other members of MWCs are drawn Group $A$ ($G_{A1}$) and Group $B$ ($G_{B1}$), possessing resources $r(G_{A1})$ and $r(G_{B1})$, and choosing labels so that $r(G_{A1}) \geq r(G_{B1})$. In Case 2, country $i$ may be a member of only one MWC, which has exactly half the system’s resources without $i$. Here label the members of the one MWC other than country $i$ itself Group $A$ ($G_{A2}$), and the countries outside this MWC Group $B$ ($G_{B2}$). Because $r(G_{A2}) = R/2$, we know that $r(G_{A2}) > r(G_{B2})$.

The proof proceeds by considering a three-part partition of all possible threats against country $i$. Either the threat originates from one or more countries in Group $A$ (either $G_{A1}$ or $G_{A2}$), or from one or more countries in Group $B$ (either $G_{B1}$ or $G_{B2}$), or from a group of countries drawn from both Groups (either $G_{A1}$ and $G_{A2}$, or $G_{B1}$ and $G_{B2}$). Threats of all three types may involve one country gaining enough resources to reach $R/2$. Consider now the possibility of a threat that divides the rest of the system, such that the two attacking countries each end up with half the resources. Such a ‘marriage’ threat must emanate from both groups, since it must be proposed by two countries together possessing more than $R/2$. If no threats or counterthreats can be implemented, because $i$ has an initiator-dependent counterthreat to every threat, then there is resource stability.11

(i) First consider threats originating from countries in Group $B$. For Case 1, country $i$...
can join with members of Group A to form a MWC attacking and absorbing Group B, with all members to gain at least some small amount of resources. All the countries are better off. Moreover, the counterthreat is not possible if country i opposes it, since Group A has fewer resources than i combined with Group B. Therefore, the counterthreat is initiator-dependent.

For Case 2, a counterthreat is formed in exactly the same way between i and Group A. Note that the counterthreat is initiator-dependent. Group A has the same amount of resources as i combined with Group B, but Group A must have more resources to make the counterthreat over i’s opposition.

(ii) Now consider threats originating from countries in Group A. For Case 1, country i can join members of Group B to form a MWC attacking and absorbing Group A, with all members to gain at least some small amount of resources. The counterthreat is not possible if country i opposes it, since Group B has fewer resources than i combined with Group A. Therefore, the counterthreat is initiator-dependent.

Case 2 is more complicated. Country i can join the Group A countries in attacking Group B. Suppose all countries in Group B have more resources than i. Then Group A’s initial threat against i cannot have threatened a group of countries with as many resources as Group B. (Country i was threatened and Group A has only half the total resources, so that the threatened group must exclude at least one country in Group B. If this country has more resources than i, then Group A’s initial threat against i cannot have threatened a group of countries with as many resources as Group B.) Therefore, the countries in Group A can collectively gain more resources by joining i to attack Group B. The only way they could not all be made better off is if one stood to gain enough resources in the initial threat to reach half the total resources. In that case, the threat can be amended so that country i transfers some small amount of resources to the country that stood to gain half, leaving some country in Group B with an equivalent small amount remaining. Then all countries in Group A can be made better off even though one stood to gain half the resources (all through seizure) in the initial threat. (Note also that for resource-stability to hold, there must be counterthreats to the counterthreats that have resource transfer elements, so that no resources actually have to be transferred. See (v) below.)

We are left with the cases where there are one or more countries in Group B with less than or the same resources as country i. If Group A initially threatened country i along with the rest of Group B, except for one or more countries with resources that together are less than or equal to those of country i, then a coalition of country i and Group A attacking Group B cannot yield more than the initial threat. But in that case, all of Group A must be participating in the threat. Why? Note that all members of Group A must have the same or more resources than i. (Otherwise a member of Group A could be switched to Group B, and we would be back with Case 1.) By assumption, Group A is threatening a coalition including i plus Group B minus a subset of Group B with the same or less resources than i, i.e. a coalition with resources greater than or equal to R12 - r1. But Group A without any one of its members does not have enough resources to attack a coalition with R12 - r1. If all of Group A is attacking, then i along with Group B has a counterthreat in which Group A’s attack is blocked, and then Group A, less its smallest member, is attacked. This counterthreat is initiator-dependent, because i is necessary to block Group A’s threat.

(iii) Finally, consider the cases where the initial threat comes from two or more countries, where at least one country comes from both Group A and Group B. Leave aside ‘marriage’ threats. (See (iv) below.) First take
Case 1. Suppose initially that no country stands to gain half the resources in the initial threat. Consider the initiator-dependent counterthreat formed by country $i$ with members of Group $B$ to attack Group $A$. More resources will be available to distribute to the Group $B$ members of the initial threatening coalition and any new members, unless the Group $B$ members of the initial threatening coalition stood to gain at least $r(G_{AI})$. 

Now consider the initiator-dependent counterthreat formed by country $i$ with members of Group $A$ to attack Group $B$. More resources will be available to distribute to the Group $A$ members of the initial threatening coalition and any new members, unless the Group $A$ members of the initial threatening coalition stood to gain $r(G_{BI})$. But both cannot occur simultaneously. Because $r(G_{AI}) + r(G_{BI}) > R/2$, the initial threat cannot have controlled this amount of resources for redistribution. Hence, at least one of the two initiator-dependent counterthreats must have sufficient resources to make all its members better off.

Suppose now that some country $j$ stands to gain up to half the resources $(R/2 - r_j)$ in the initial threat. The initial threat could at most have garnered $R/2 - e$ for the whole attacking coalition, where $e$ is some small amount of resources. So, not including $j$, the resources available to the members of the initial threatening coalition could be at most $R/2 - e - (R/2 - r_j) = r_j - e$. But then the initiator-dependent counterthreat by country $i$ with members of the Group not containing $j$ against the Group (either $A$ or $B$) containing $j$ yields at least $r_j$, enough to make the counterthreatening coalition members better off.

Now take Case 2. Consider the initiator-dependent counterthreat formed by country $i$ with Group $A$ to attack Group $B$. This will provide $r(G_{B2}) = R/2 - r_i$ for distribution, so that Group $A$ members can be made better off unless they stood to gain at least $R/2 - r_i$. Suppose that Group $A$ members did stand to gain at least $R/2 - r_i$. By adding transfers from its own resources, country $i$ can bring the total for distribution up to $R/2 - r_i + (r_i - e) = R/2 - e$. This can be made greater than the total amount available to Group $A$ members of the initial threatening coalition, which must be strictly less than $R/2$. If one of the Group $A$ members stood to gain enough resources in the initial threat to reach $R/2$, then this country can be made better off with a small transfer. (Note that $i$ may potentially have to make greater concessions in Case 2, because $i$ does not have sufficient resources along with Group $B$ to attack Group $A$, i.e. it may be that $i$ is only a member of one MWC. In this case, $i$ may be in a difficult position if attacked by one or more members of Group $A$.)

(iv) Suppose that $i$ is attacked as part of a marriage threat. Again, it must be that one attacker is in Group $A$ and one in Group $B$. For they must have over $R/2$ together to make a marriage threat, and (in both Cases 1 and 2) neither Group $A$ nor Group $B$ exceeds $R/2$ in size. In Case 1, country $i$ chooses Group $A$ to make a counterthreat on Group $B$. Label the initial attacker in Group $A$ country $j$. Country $i$ and Group $A$ attack Group $B$, but seize only $r(G_{B1}) - e$, where $e$ is some small amount. This small amount $e$ is transferred by $i$ to $j$, thus making $j$ better off than in the initial attack where all the resource gains had to be achieved by fighting. Any other participating countries in Group $A$ are better off, since the other country in the initial threatening coalition, now being targeted for seizure as part of Group $B$, has more resources than what is necessary to bring up to $R/2 - e$. The counterthreat is viable because Group $A$ cannot both attack Group $B$ and extract a transfer from $i$. Case 2 proceeds identically.

(v) Note that all the cases above where transfers are made also involve seizures from other countries. Initiator-dependent counterthreats can be made by all these countries
according to (i)–(iii) above. Note that it cannot be the case that the transfers necessary to counter all counterthreats will grow over time until they become infeasible. Higher transfers than in the previous counterthreat only need occur where it is necessary to offer the same country a transfer in consecutive rounds. This may happen in two situations.

In one situation, the country was offered a small transfer in addition to seized resources sufficient to bring it up to R/2. Here the additional transfer offered in the next round can simply be made a lower order of magnitude than the first, so that they can never add up to an infeasibly large sum. Moreover, the original and any subsequent transfer offered can be made small enough so that any country selected to make the next counterthreat can offer an improved transfer. In another situation, one or more countries received transfers in Case 2 scenarios where i is a member of only one MWC. In these situations, i may have to make transfers to increase the resources to be gained by some members of the previous threatening coalition. Any additional transfers necessary in the next round for some other country in a similar position can simply be made so as to produce the same gains with a slight improvement. Again, the increment of improvement over the previous round can be made a lower order of magnitude than the first, so that they can never add up to an infeasibly large sum. Moreover, the original and any subsequent transfer offered can be made small enough so that any country selected to make the next counterthreat can offer an improved transfer. In both situations, the improvement over the previous round can be made a lower order of magnitude than the first, so that they can never add up to an infeasibly large sum. Moreover, the original and any subsequent transfer offered can be made small enough so that any country selected to make the next counterthreat can offer an improved transfer. In both situations, the improvement over the previous round can be made a lower order of magnitude than the first, so that they can never add up to an infeasibly large sum. Moreover, the original and any subsequent transfer offered can be made small enough so that any country selected to make the next counterthreat can offer an improved transfer.

There is therefore an initiator-dependent counterthreat to every threat or counterthreat for all countries i, and no resources are ever seized or transferred. This completes the proof.

Proof of Resource Stability under Assumption 8.2
Here, it is shown that no transfers need be used to counter threats except in cases where the initial threat is a ‘marriage’. Consider the same three-part partition of possible threats as in the proof under Assumption 8.1.

(i) For threats emanating from Group B, use the same all-seizure counterthreats as in the main proof.

(ii) For threats emanating from Group A, use the same all-seizure counterthreats as in the main proof for Case 1. Now consider Case 2. Group B along with country i can construct an initiator-dependent counterthreat against Group A less Group A’s smallest country. The coalition is formed by subtracting the smallest country from the combination of Group B with country i until subtracting another would give the coalition less or the same resources as Group A less Group A’s smallest country. This counterthreat is initiator-dependent, since it cannot be made if one more country is withdrawn. Unless Group A as a whole participated in the initial threat, this counterthreatening coalition is larger than the initial threatening coalition. If Group A

\[ \text{Consider the initial distribution } (30,26,24,20-e,4,e), \text{ where e is some small amount. The last three countries are only members of one MWC – by individually joining 26 and 24 – so the example falls under Case 2. Suppose 30 and 26 together propose to seize resources from 24, 20-e, and 4+e, to produce a new distribution } (50,0,0,0,0+e). \text{ Suppose } 5+e \text{ is randomly selected to make the counterthreat. The counterthreat must involve joining 26 and 24 in attacking the rest of the system, and making an additional transfer to make 26 better off than under the original threat. If the transfer offered is greater than or equal to } 5+e, \text{ then the counterthreat would actually have to transfer } 5+e. \text{ Therefore, } 5+e \text{ would be sure to offer a smaller transfer, so that } 4+e \text{ would if necessary be able to offer a counterthreat to } 4+e \text{’s counterthreat.} \]
as a whole made the initial threat, then a counterthreat is formed by country $i$ with all of Group $B$. This coalition blocks the initial attack, and then attacks Group $A$ less Group $A$'s smallest country. This second counterthreat is initiator-dependent, because the initial attack cannot be blocked without all member countries participating.

(iii) For non-marriage threats emanating from both Group $A$ and Group $B$, use the same all-seizure counterthreats as in the main proof for Case 1. Now consider Case 2. Suppose that no country in the initial threatening coalition stands to gain up to $R/2$. First try an initiator-dependent counterthreat of country $i$ with Group $A$ against Group $B$. This fails only if the Group $A$ members of the initial threatening coalition stood to gain at least $r(G_{A2}) = R/2 - r_i$. Suppose that this is so. In that case, construct another counterthreat attacking Group $A$ less Group $A$'s smallest country. (Call the latter $min_A$, with resources $r_{min_A}$.) Start with Group $B$ along with country $i$, and subtract the smallest country until no more can be withdrawn without rendering the counterthreat impossible. Such a counterthreat is therefore initiator-dependent. The members of the initial threatening coalition participating in this second counterthreat are not made better off only if they stood to gain at least $r(G_{A2}) = R/2 - r_{min_A}$. For this to be so as well, it must be that $R/2 - r_i + R/2 - r_{min_A} < R/2$, which is the same as $R/2 < r_i + r_{min_A}$. Otherwise the initial threatening coalition will have had to capture $R/2$ or more, which is not possible. We know that $r_i \leq r_{min_A}$. If not, we can withdraw $r_{min_A}$ from Group $A$, and we are back with Case 1. Since there must be at least two countries in Group $A$ – otherwise some country has $R/2$ resources and resource-stability follows immediately – it must be that $r_{min_A} \leq R/4$. So we have $r_i + r_{min_A} \leq r_{min_A} + r_{min_A} \leq R/4 + R/4 = R/2$. Therefore, one of the two counterthreats must make all of its members better off than under the initial threat.

Now, consider the situation where some country $j$ in the initial threatening coalition stands to gain up to $R/2$. Construct a counterthreat against country $j$ by starting with the rest of the system and eliminating the smallest country until the coalition $C'$ is minimum-winning. A counterthreat by this coalition against the rest of the system is initiator-dependent. The initially threatening members and any new members participating in the counterthreat are better off if $R - C' > R/2 - e - (R/2 - r_j)$. This is the same as $R + e > C' + r_j$, which holds given that $j$ is not a member of $C'$.

So no transfers are necessary to construct counterthreats against non-marriage threats.

Note that it is straightforward to apply the proof of resource stability under Assumption 8.2 to the case of countries that are not members of MWCs. Take any given proposed redistribution that exclusively targets the resources of one or more such countries. (The proof already covers proposed redistributions that also target members of MWCs.) Wherever the proposed redistribution originates, the proof shows there are countries in MWCs with initiator-dependent counterthreats that offer them preferred resource distributions, and that there are initiator-dependent counterthreats to these counterthreats, and so on.

References


Addendum

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In the body of the *Journal of Peace Research* article, resource stability proofs are presented under the assumptions that all threatened countries must have initiator-dependent counterthreats, and that at least one threatened or neutral country must have initiator-dependent counterthreats. The ways in which counterthreats were made to different types of threats is shown in Table I (located at the end of this addendum). Here a similar resource stability proof will be provided for the somewhat different set of assumptions made by Niou and Ordeshook (1986) and Niou, Ordeshook and Rose (1989). First their assumptions and definitions will be stated, and the differences indicated. The main differences are Definition 5 and Assumption 8. The proof of resource stability follows.

**Assumptions and Definitions**

*Assumption 1:* The total amount of resources in the system, \( R \), is constant, divisible and transferable.

*Assumption 2:* Any coalition \( C^a \), made up of one or more countries \( i, j, k, \ldots \), with more resources than another coalition \( C^b \), can propose that \( C^b \)'s resources be redistributed by seizure. Any coalition \( C^a \) can also propose, either separately or along with a redistribution
of $C^b$'s resources, that some resources of one or more of its own members be redistributed by transfer.

Note: Niou and Ordeshook do not discuss the possibility of a hybrid seizure-transfer counterthreat. But neither is it excluded by their discussion, which allows both seizures and transfers.

Assumption 3: Such proposed redistributions are implemented unless there is some other coalition $C^c$, which is able to dominate $C^b$, proposing another redistribution. $C^c$ can dominate $C^b$ either if it has greater resources. $C^c$ may acquire sufficient resources to dominate $C^b$ by attracting away one or more members of $C^b$.

Note: The assumption made here, that a coalition must have greater resources in order to supplant another coalition, is stronger than in the article. There it is assumed that it is sufficient to have greater or equal resources.

Assumption 4: Countries participate in coalitions proposing to redistribute resources if and only if the proposed redistribution leaves them better off with certainty than if they did not participate. They are better off either if they are left with more resources, or if they are left with the same resources but with a larger share obtained by transfer as opposed to seizure from other countries. Countries are better off with certainty if they can be sure that a proposed redistribution making them better off will not make them worse off later in the game.

Assumption 5: If all of a country’s resources are eliminated as a result of a redistribution, then that country ceases to exist.

Assumption 6: Each play of the game consists of a sequence of proposed redistributions, with proposals being succeeded by other, dominating proposals, until some undominated
proposal is made and then implemented. (‘Undominated’ is further defined in Assumption 8 below.) There is no imposed limit on the number of proposals in each play of the game, or on the number of plays in a game.

**Assumption 7:** There is complete information about the rules of the game and about the preferences and resource endowments of all the countries.

**Definition 1:** A system of countries with a given resource distribution at the start of one of the plays of the game is *system-stable* if no country can be eliminated through proposed redistributions that are implemented.

**Definition 2:** A system of countries with a given resource distribution at the start of one of the plays of the game is *resource-stable* if no country’s resource endowment can be changed through proposed redistributions that are implemented.

**Definition 3:** A proposed redistribution by \(C^a\) at the expense of \(C^b\) is a *threat* if (a) it is the first proposal in a given play of the game, (b) all members of \(C^a\) are to end up with more resources than they start with at the beginning of the play, (c) all members of \(C^b\) are to end up with fewer resources than they start with at the beginning of the play, and (d) \(C^a\) has more resources than \(C^b\).

**Definition 4:** A proposed redistribution by \(C^c\) is a *counterthreat* if (a) it follows a threat or another counterthreat in a given play of the game, (b) all members of \(C^c\) end up better off than they would have been if the previous threat or counterthreat was implemented, (c) \(C^c\) has more resources than the coalition making the previous threat or counterthreat, and (d) either

- the proposal exclusively involves seizing resources from \(C^d\), or
• the proposal exclusively involves transferring resources from one or more members of $\mathcal{C}^e$ to one or more other members of $\mathcal{C}^e$ (the latter may or may not be members of the coalition making the previous threat or counterthreat), or

• the proposal involves a combination of seizing resources from $\mathcal{C}^d$, and transferring resources from one or more members of $\mathcal{C}^e$ to one or more other members of $\mathcal{C}^e$.

Note: Again, here more resources are required under (c), and the possibility of hybrid seizure-transfer counterthreats is explicitly recognized.

Definition 5: A counterthreat by $\mathcal{C}^e$ is viable if the proposing country $i$ is necessary for $\mathcal{C}^e$ to make the counterthreat, i.e. if $\mathcal{C}^e$ without $i$ has less than or the same resources as $\mathcal{C}^d$ in the case of a proposed seizure, or insufficient resources to make a proposed resource transfer feasible.

Assumption 8: A threat or counterthreat is undominated and hence implemented unless the first country responding, which is randomly selected from among the countries targeted for resource seizures, can propose a viable counterthreat.

Note: Viability is a stronger requirement than initiator-dependence. Initiator-dependent counterthreats can be nonviable in cases where $i$’s active opposition is sufficient to block $\mathcal{C}^e$ from making the counterthreat.

Resource Stability Proof

Proof of Resource Stability using Niou & Ordeshook’s (1986) Assumptions, Including the Viability Criterion:

Suppose all countries are members of at least one minimum winning coalition (MWC), and that all possess less than half the resources in the system. Consider the same three-part partition of possible threats as in the main proof (see the article’s Appendix).
(i) Start with threats from Group B under Case 1. The counterthreat of members of Group A with country i against Group B in the original proof is not necessarily viable except in the special case where \( r(G_A) = r(G_B) \). In the typical case where \( r(G_A) > r(G_B) \), country i may not be necessary for members of Group A to attack Group B. In Case 2, the proposed counterthreat in the original proof is not viable for the same reason. In both Cases, the proposed counterthreats can be rendered viable by i transferring a small amount to Group A members to supplement the resources seized from Group B. This small transfer makes the counterthreat viable, because Group A cannot attack all of Group B and extract a transfer from i at the same time.

(ii) Threats from Group A under Case 1 can be countered viably just as in the original proof, because Group B cannot attack Group A alone. For Case 2, a different approach must be used to construct a viable counterthreat. Under the original threat, Group A members stand to gain at most \( \frac{R}{2} - r_{\text{min}B} \), where \( r_{\text{min}B} \) is size of \( \text{min}B \), the smallest country in Group B. Suppose initially that no member of the initial threatening coalition stands to gain up to \( \frac{R}{2} \). Suppose i joins Group A in attacking Group B. If \( r_i < r_{\text{min}B} \), Group A members stand to gain \( \frac{R}{2} - r_i > \frac{R}{2} - r_{\text{min}B} \), and hence are better off. This counterthreat can be made viable if i transfers an additional small amount. This is because Group A cannot both attack Group B and extract a transfer from i at the same time. If \( r_i \geq r_{\text{min}B} \), then i can add sufficient transfers to allow Group A members to gain \( \frac{R}{2} - r_{\text{min}B} + e \). This counterthreat is viable because Group A cannot attack Group B and extract transfers from country i at the same time. Suppose a member of A stood to gain up to \( \frac{R}{2} \) under the initial threat. Then some small transfer can be given to that country to make it better off.
In the scenarios where \( r_i \geq r_{\text{minB}} \), this will still leave country \( i \) with resources at least equal to \( r_{\text{minB}} - e \).

(iii) Suppose the threat originates from countries drawn from both Group A and Group B. In Case 1, the approach in the original proof does not necessarily work unless \( r(G_{A1}) = r(G_{A2}) \). So start with the counterthreat of country \( i \) with Group B against Group A. Members of the initial threatening coalition in Group B could not stood to gain more than \( R/2 - e_1 \). By adding sufficient transfers where necessary, country \( i \) can provide Group B with \( R/2 - e_2 \) (where \( e_2 < e_1 \)). If some country \( j \) in Group B stood to gain up to \( R/2 \), that country can be made better off by receiving some small transfer. This counterthreat is viable because Group B cannot attack Group A without country \( i \). An identical approach can be used for Case 2, except country \( i \) joins Group A in an attack on Group B. In this case, \( i \) must always make some transfer to Group A to supplement the resources taken from Group B. Otherwise the counterthreat is not viable.

(iv) Marriage threats can be countered just as in the original proof for both Case 1 and Case 2. This is because a transfer by country \( i \) is necessary. Since Group A cannot both attack Group B and extract a transfer from country \( i \), such hybrid seizure-transfer counterthreats are viable.

(v) Note that all the cases above where transfers are made also involve seizures from other countries. Viable counterthreats can be made by all these countries according to (i)-(iii) above. Note that it cannot be the case that the transfers necessary to counter all counterthreats will grow over time until they become infeasible. Higher transfers than in the previous counterthreat only need occur where it is necessary to offer the same country a transfer in consecutive rounds. This may happen in two situations.
In one situation, the country was offered a small transfer in addition to seized resources sufficient to bring it up to $R/2$. Here the additional transfer offered in the next round can simply be made a lower order of magnitude than the first, so that they can never add up to an infeasibly large sum. Moreover, the original and any subsequent transfer offered can be made small enough so that any country selected to make the next counterthreat can offer an improved transfer. In another situation, one or more countries received transfers where $i$ is not necessarily a member of a MWC with a viable counterthreat against the rest of the system. In these situations, $i$ may have to make transfers to increase the resources to be gained by some members of the previous threatening coalition. Any additional transfers necessary in the next round for some other country in a similar position can simply be made so as to produce the same gains with a slight improvement. Again, the increment of improvement over the previous round can be made a lower order of magnitude than the first, so that they can never add up to an infeasibly large sum. Moreover, the original and any subsequent transfer offered can be made small enough so that any country selected to make the next counterthreat can offer an improved transfer. Note that all countries have an incentive not to propose transfers or increases in transfers that make it impossible for some other country to counter in the next round. This is because all countries wish to avoid making transfers in practice, which they have to do if their counterthreat cannot itself be countered.

Therefore there is a viable counterthreat to every threat or counterthreat for all countries $i$, and no resources are ever seized or transferred. This completes the proof.
Table I. Necessary Types of Counterthreats to Preserve Resource-Stability under Different Requirements and Conditions

<table>
<thead>
<tr>
<th>Origin of Initial Threatening Coalition</th>
<th>Case 1</th>
<th>Case 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>Group B</td>
<td>Groups A and B</td>
</tr>
<tr>
<td>All threatened countries must have initiator-dependent counter-threats.</td>
<td>Only <em>seizure</em> counter-threats necessary.</td>
<td>Only <em>seizure</em> counter-threats necessary.</td>
</tr>
<tr>
<td>At least one threatened or neutral country must have initiator-dependent counter-threats.</td>
<td>Only <em>seizure</em> counter-threats necessary.</td>
<td>Only <em>seizure</em> counter-threats necessary.</td>
</tr>
<tr>
<td>All threatened countries must have viable counter-threats.</td>
<td>Only <em>seizure</em> counter-threats necessary.</td>
<td>Along with <em>seizure</em> counter-threats, <em>hybrid seizure-small transfer</em> counter-threats may be necessary.</td>
</tr>
</tbody>
</table>

Note: In the case of threats originating from both Group A and Group B, ‘marriages’ - in which two countries propose to divide the entire system so that each possesses half the
resources - are excluded. Counterthreats to marriage proposals must always involve transfers.