Power Transfers, Military Uncertainty, and War

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September 14, 2018

Abstract

In many contexts, patrons wish to simultaneously increase a protégé's military power while reducing the probability of war between that protégé and its enemy. Are these goals compatible? I show that the answer is yes when states face uncertainty over military allotments. Arms transfers mitigate the information problem by making both strong and weak types behave more similarly. This encourages uninformed states to make safer demands, which decreases the probability of war. As a result, transfers to the informed actor both increase bargaining power and enhance efficiency under these conditions.

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1 Introduction

Military aid and military transfers have become commonplace in international relations. According to the SIPRI Arms Transfers Database, the world accumulated more than $28 billion in arms exports in 2012. The United States alone transfered about $630 billion from 1950 to 2012, with per annum exports routinely going above $12 billion during the Cold War. Military aid extends to the realm of civil conflicts, with about four in five rebel groups receiving assistance during some eras (Grauer and Tierney, 2017).

The reason states give aid is obvious. If a protégé and a mutual enemy were to fight a war, the patron would like to see the protégé emerge triumphant more often. Military aid achieves that goal. Meanwhile, if a protégé and a mutual enemy were to negotiate a settlement, the patron would like to see the protégé receive a better share. Because peaceful settlements must be commensurate with a state's share of the power (Fearon, 1995), military aid again achieves that goal.

Nevertheless, patron states often have a competing incentive. The United States, for example, would like South Korea to better coerce North Korea. But the United States does not want to see war on the Korean Peninsula, if for no other reason than the deleterious effects on the world economy. Transfers are therefore beneficial holding fixed either a peaceful outcome or a war outcome. However, transfers could backfire if they take an otherwise peaceful outcome and subvert it into a war outcome, even if that war outcome is better than a war outcome without a transfer.

Can transfers affect the probability of conflict? The existing literature provides a mix of answers. Kuperman (2008) worries the answer is yes—by aiding potential rebels, patrons cause protégés to take more risks than they would otherwise, leading to more wars occurring. Kinsella (1994) provides evidence in the affirmative, at least in regard to some U.S. transfers during the Cold War. And in a related topic area, scholars debate whether alliances—which also endow their benefactors with greater military capacity—have a deterrent, provocative, or moral hazard inducing net effect (Waltz, 1979; Leeds, 2003; Benson, Meirowitz and Ramsay, 2014).

In this paper, I provide a clear, if partial, theoretical answer: when a state is uncertain about its opponent's military allotments, transfers to the informed party suppress conflict. Put differently, patron states can have their cake and eat it too in these cases, both empowering their protégés and reducing the probability of war.

Despite generating an expectation similar to what the deterrence literature offers, the mechanism is distinct and rests on informational concerns. An extreme example helps illustrate the intuition. Suppose that A faces uncertainty over B's *military resources*, like its quantity of weapons, vehicles, soldiers, and so forth.[1] To put more structure on the problem, imagine that A does not know whether B has 1 or 100 tanks. The true quantity determines the offer A would want to make, as the type with only 1 tank is helpless whereas the type with 100 stands a real chance at winning a war. Because obtaining peace with the 100 tank type requires a vast overpayment to the 1 tank type, A may prefer making an aggressive demand that only the 1 tank type would accept, leading to war with the 100 tank type.

Now suppose a patron gives B 1000 additional tanks. The substantive difference between the 1 tank type and the 100 tank type becomes less relevant. After all, the marginal difference in power a country has with 1100 tanks and 1001 tanks is relatively small compared to 100 tanks versus 1 tank. Making peace with the more powerful type therefore requires a smaller overpayment to the less powerful type. In turn, A has more incentive to issue safer demands, and thus the probability of war declines. Put differently, the transfer mitigates A's information problem.

To be clear, I do not claim that power transfers have a universally pacifying effect on crisis bargaining. In fact, it is definitely not true. Benson, Meirowitz and Ramsay (2016) show that transfers can provoke more war when the value of one state's gains do not offset the other side's losses for a range of the policy space. However, their paper analyzes uncertainty over the costs of war. My paper instead discusses how shifting power alters incentives for war when the states face uncertainty over that facet of coercive bargaining. The fact that the manipulation could influence uncertainty indicates that the results may be different, and I verify this.

Nevertheless, the differences between Benson, Meirowitz and Ramsay (2016) and my work suggest caution in developing policy recommendations based on any formal results from the bargaining model of war. I do not argue that patron states should blindly supply weapons to their protégés. Rather, as Fey and Ramsay (2011) demonstrate,

[1] Such uncertainty can arise from previous investment decisions (Meirowitz and Sartori, 2008) or the inability to observe existing military resources (Walter, 1999; Fearon, 2007). It is also the basis of the "German tank problem," in which allies tried to estimate the quantity of Nazi tanks produced during World War II based on the serial numbers observed in battle.

the type of uncertainty states face has different theoretical and empirical implications. My model underscores that point. International relations scholars should not treat uncertainty as a monolithic mechanism. Instead, they should consider how specific types of uncertainty affect conflict patterns.

2 The Mechanism

I begin with a simple model that illustrates the mechanism before obtaining a more general result. The first hurdle in the analysis is modeling uncertainty over the probability of victory. Standard models—e.g., Reed (2003) and Slantchev (2003)—blackbox this as various different possible p values. This is suitable for most research questions, but my research question asks how power transfers affect crisis bargaining with uncertainty over the probability of victory. Thus, I need to explicitly account for what causes those p values to vary and how transfers affect them.

The cases I cover are situations where the uncertainty over p stems from one side not knowing the quantity of the other's military allotments. For example, Arena and Pechenkina (2016) consider a game in which the probability of victory is a function of a standard ratio contest function, but State A does not know whether State B has $\underline{m}_B > 0$ resources or $\overline{m}_B > \underline{m}_B$ resources.[2] I speak to this source of uncertainty. However, I generalize the functional form over the probability of victory to better understand the properties of military transfers necessary to incentivize peace.[3]

I consider a two player game because the interesting question is how the bargaining outcomes change as a function of the transfer; later, I briefly describe what the results imply about an endogenous transfer from a third party. The game begins with Nature drawing B's military resources as $\underline{m}_B$ with probability q and $\overline{m}_B$ with probability $1-q$; the draw determines B's probability of victory in a manner I describe in a moment. B

[2]Given ratio contest functions, A would win with probability $\frac{m_A}{m_A+\underline{m}_B}$ in the first case and $\frac{m_A}{m_A+\overline{m}_B}$ in the second case. Thus, not knowing B's allotments means A does not know whether it is more or less likely to win.

[3]An alternative source for uncertainty over the probability of victory is *martial effectiveness*, or "unit cohesion, esprit de corps, professionalism, leadership, bravery, ingenuity, and morale" (Arena, 2013). That is, one state may know whether its opponent has 1 or 100 tanks, but it does not know how well its tank drivers are trained or whether they will follow commands as prescribed. In the appendix, I show that the results are more nebulous than the case with uncertainty over military allotments. Transfers interact with the source of the information problem here, which can exacerbate the information problem in the short-term.

observes the draw but A does not. In the dark, A demands $x \in [0, 1]$, a share of the policy in dispute between the two. B sees the demand and accepts or rejects. Accepting implements the settlement while rejecting yields war.

Payoffs are as follows. If B accepts, each receives its share of the division: x for A and $1 - x$ for B. If B rejects, the states fight a war. The payoffs for both sides depend on B's type. The function $p(m_B + t) \mapsto [0, 1]$ maps the quantity of military resources B possesses—through its domestic capacity (m_B) and resources transfered to it (t)—to A's probability of victory. If B has fewer resources, A earns $p(\underline{m}_B + t) - c_A$ and B earns $1 - p(\underline{m}_B + t) - c_B$. As in the standard model, $c_i > 0$ represents each party's cost of war.[4] If B has more resources, the war payoffs are $p(\overline{m}_B + t) - c_A$ and $1 - p(\overline{m}_B + t) - c_B$.

These utility functions clarify what A knows and what it does not. In particular, it cannot observe B's own military capacity. It can, however, see any transfer B receives. This is the interesting case. It would not be surprising if an uncertain transfer exacerbated A's information problem and increase incentives for war. Nevertheless, given the substantive pitch, this is a reasonable assumption to make. A government may be unable to observe a rebel groups' own capabilities, but they can see agreements that the United States makes to transfer armaments.[5]

I only make two assumptions about the function p: its first derivative is negative and its second derivative is positive. Substantively, the first derivative means that A's probability of victory decreases as B's total resources increase. For example, the more tanks B has, the more likely B is to win and the more likely A is to lose. The second derivative implies that military resources have diminishing marginal returns.[6] That is, the benefit B gains going from 5 tanks to 6 is greater than the benefit B gains going

[4]In this manner, the costs of war are not a function of the transfer. As the cutpoints derived below clarify, the central result holds as long as the net total costs (i.e., $c_A + c_B$) increase in the transfer. This is a reasonable expectation—more guns ought to lead to more overall deaths, even if they shift the distribution away from their recipient.

[5]Moreover, a patron state wishing to minimize war between the two states has incentive to make the transfer transparent so as to not induce war. Outside of that case, if transfers are verifiable, the unraveling principle implies that B would want to make them public, and A would share the desire to transmit accurate information about the quantity. Regardless, an uncertain quantity of transfers can still have a pacifying effect if the variance-reducing property of possible transfers dominates the variance-increasing property of the uncertain transfer. Put differently, opaque transfers with sufficiently small noise still induce peace.

[6]The direction of these derivatives may be confusing because p maps to A's probability of victory. From B's perspective, its probability is $1 - p(m_B + t)$. This has a positive first derivative and a negative second derivative, which are the intuitive directions.

from 900 tanks to 901. This is a critical assumption for the results below, but it is also the natural way to think about how military resources aggregate.

Now to the game's equilibrium. I focus on cases where the weakest type of of B has a positive value for war in the absence of a transfer.[7] Although this may seem to be for mathematical convenience, it has critical theoretical implications, which I return to below. By backward induction, the low type is willing to accept when $1 - x \geq 1 - p(\underline{m}_B + t) - c_B$, or $x \leq p(\underline{m}_B + t) + c_B$.[8] Analogously, the high type is willing to accept when $x \leq p(\overline{m}_B + t) + c_B$.

Three points immediately follow from this. First, A would never demand $x > p(\underline{m}_B + t) + c_B$. Doing so induces both types to reject, whereas A could deviate to offering just enough to induce the low type to accept. Second, A would never demand $x \in (p(\overline{m}_B + t) + c_B, p(\underline{m}_B + t) + c_B)$. Doing so induces the high type to reject and gives more than what is necessary to induce the low type to accept. A could therefore profitably deviate to a slightly larger amount (but still less than the low type's reservation value). This yields the same war payoff versus the high type but improves A's settlement against the low type. Finally, A would never demand $x < p(\overline{m}_B + t) + c_B$. This quantity is more than necessary to induce both types to accept. A could therefore profitably deviate to a slightly larger amount (but still smaller than $p(\overline{m}_B + t) + c_B$) and keep more of the settlement.

The two possibilities remain: $p(\overline{m}_B + t) + c_B$ and $p(\underline{m}_B + t) + c_B$. The first induces both types to accept, while the second induces only the low type to accept. Comparing the expected utilities for each decision, A prefers making the risky demand $p(\underline{m}_B + t) + c_B$ if:

$$q(p(\underline{m}_B + t) + c_B) + (1 - q)(p(\overline{m}_B + t) - c_A) > p(\overline{m}_B + t) + c_B$$

$$q > q^* \equiv \frac{c_A + c_B}{p(\underline{m}_B + t) - p(\overline{m}_B + t) + c_A + c_B} \qquad (1)$$

Analogously, A makes the safe demand $p(\overline{m}_B + t) + c_B$ if $q < q^*$.

My main substantive interest is how incentives for war change as a function of the

[7] Formally, this requires $\frac{m_B}{m_A + \underline{m}_B} - c_B > 0$.

[8] When $x = p(\underline{m}_B + t) + c_B$, B is indifferent between accepting and rejecting. For the standard reasons, no equilibria exist when B rejects with positive probability when indifferent, and thus the remainder of the proof assumes that B accepts with probability 1 when indifferent.

parameters. Note that increasing q^* contracts the range for which A makes the risky offer and expands the range for which A makes the safe offer. Therefore, if increasing a parameter increases q^*, then an increase to that parameter shrinks the parameters under which war occurs. Doing so also weakly decreases the probability of war because it can flip that probability from $1 - q$ (when A makes the risky offer) to 0 (when A makes the safe offer).

The transfer is just such a parameter:

Proposition 1. *As t increases, the parameter space for which war occurs decreases in size, and the probability of war weakly decreases.*

The proof is a simple derivative on q^* with respect to t. For war to occur, q must exceed the cutpoint. Thus, if increasing t increases q^*, it becomes more difficult for q to fulfill the condition. Taking that derivative and investigating if it is strictly decreasing yields:

$$\frac{(c_A + c_B)\left(\frac{\partial}{\partial t}(p(\overline{m}_B + t) - p(\underline{m}_B + t))\right)}{(p(\underline{m}_B + t) - p(\overline{m}_B + t) + c_A + c_B)^2} > 0$$

$$\frac{\partial}{\partial t} p(\overline{m}_B + t)) > \frac{\partial}{\partial t} p(\underline{m}_B + t)$$

This is true—it simply states that increasing transfers incentivize peace as long as military power has diminishing marginal returns.

Figure 1 illustrates the central logic. It maps A's probability of victory as a function of the size of all military resources. As the transfer increases, B's probability of winning increases, and correspondingly A's decreases. This is the primary effect of transfers. But diminishing marginal returns distort the difference between low resource and high resource types. Indeed, their respective probabilities of victory converge together. Thus, transfers have a second-order effect of mitigating A's information problem. With the functional importance of domestic military resources diminished, A finds buying off both types more attractive.[9]

For further intuition, consider the underlying dynamics in A's risk-return trade-off. Larger offers secure peace more often but require concessions sufficient to appease

[9] Bringing potential reservation values together in this manner reduces the probability of conflict across a variety of other mechanisms (Reed, 2003; Spaniel, 2018). From a technical standpoint, this paper therefore contributes by showing that arms transfers have this effect with uncertainty over military resources.

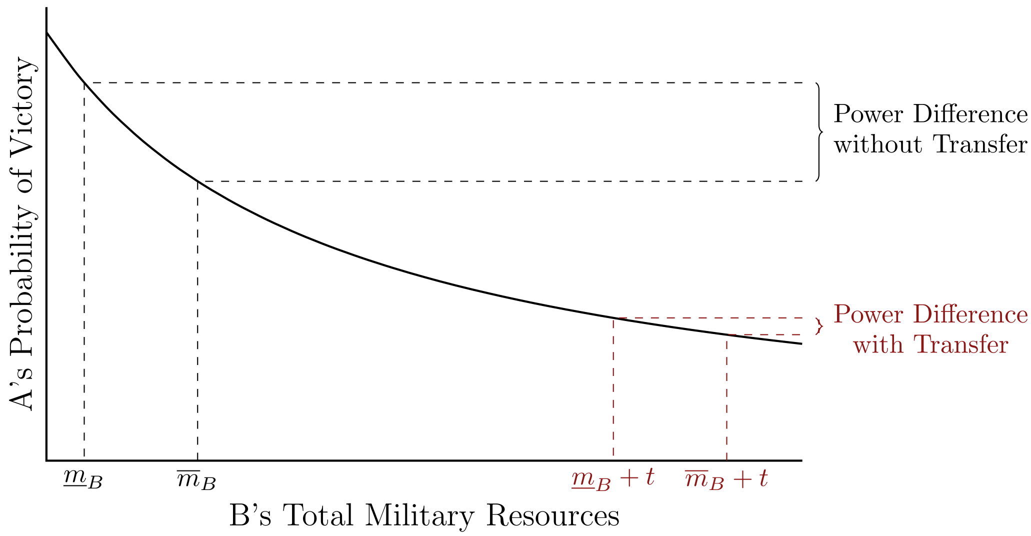

Figure 1: The difference in A's possible probability of victories with and without a transfer. Larger transfers mitigate the source of A's information problem and therefore reduce incentives for war.

stronger types. These amounts result in an overpayment to the weaker types, which Figure 2 illustrates. When that overpayment is large, making aggressive offers looks more attractive so that A can secure a greater share through the peaceful settlement. But when the overpayment is tiny, safe offers appear wiser—it is not worth trying to grab a sliver more of the pie when doing so leads to a great increase in the probability of war. Figure 1 shows that transfers make the possible types' reservation values increasingly similar and therefore has the calming effect that Proposition 1 describes.

This intuition explains why assuming non-negative war payoffs in the absence of a transfer has critical theoretical implications. If both types of B are so weak that they accept any offer from A in the absence of a transfer, then the peace is guaranteed. Increasing B's allotments can cause the stronger type's reservation value to exceed 0. At that point, further increases create a larger difference in what the types are willing to accept. This exacerbates the information problem and incentivizes A to make risky offers. However, yet further transfers put both types' reservation values above 0. Transfers then begin to exhibit the behavior described in Proposition 1.

Regardless, two questions natural questions follow from the main result. First, what do these results imply for endogenous transfer decisions from the (unmodeled)

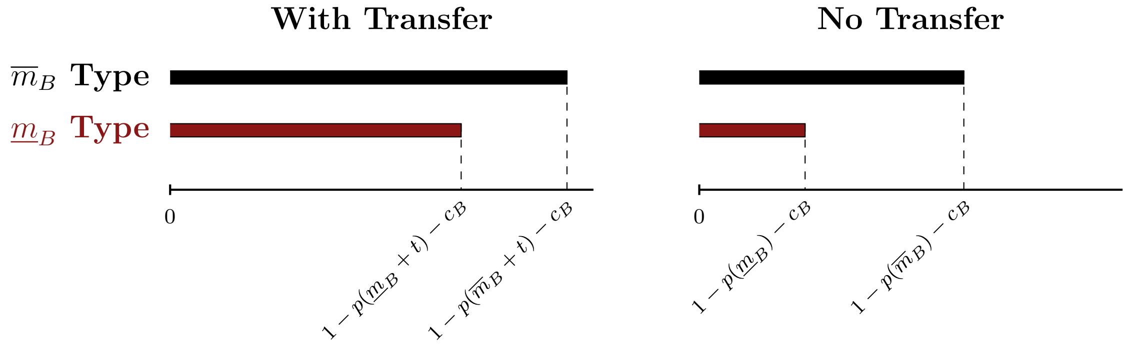

Figure 2: The difference in reservation values for each type, with and without a transfer. The safe offer requires overpaying the $\underline{m}_B$ type by a greater margin without the transfer. Thus, as transfers increase, A is more inclined to make a safe proposal.

third party? To be clear, the model only provides insight in cases where a protégé's opponent does not know the protégé's military resources. However, under this informational structure, a patron's desire to strengthen its protégé does not run contrary to a secondary desire to maintain peace. In fact, it actually creates an incentive to arm the protégé beyond where the marginal benefit exceeds the marginal cost. This is because sufficient arming generates a "deterrence surplus" (Benson, Meirowitz and Ramsay, 2014) by reducing the likelihood that the patron suffers an externality from the two players fighting. Thus, with uncertainty over military allotments, the model predicts higher overall transfers than what one might initially suspect.

That being said, it is worth asking whether a third party would ever want to make peace-assuring transfers here. Obviously, the answer would depend on that state's precise utility function. Nevertheless, further examination of Condition 1 reveals when doing so would be cheaper. Higher costs of war increase the cutpoint, requiring less work from the transfer. Likewise, a smaller belief that B is the less-armed type makes the left hand side smaller and has the same implication.[10]

The second natural question is what the third party needs to know to reduce the circumstances where war occurs. The answer is not much. It does not need private information, it does not need to know one side's belief about the other, and it does not

[10]More structure on the problem can also generate an explicit solution. I omit examples of this here because such solutions are notationally cumbersome even for simple mappings of armaments to probabilities of victory, like the standard proportional contest.

need any projections of higher orders of beliefs. All it needs to know is that the possible types of the recipient have positive values for war and that the recipient's opponent does not know the recipient's baseline capabilities. The comparative static shows that any transfer whatsoever can only promote peace in this setup.

3 A General Result

The above result helped illustrate a clear intuition for the mechanism: increasing transfers makes both low capability and high capability types act more similarly, mitigating A's information problem. Nevertheless, one may wonder how robust the result is. After all, the setup could be broadened on many levels—there could be more than two types, the distribution could be arbitrary, and the bargaining protocol could be far more detailed than a simple ultimatum.

I therefore investigate whether the result generalizes. Mechanism design provides the proper framework for this.[11] It permits investigation of what must hold across every possible extensive form one could write down that meets some minimal criteria. Moreover, I can also incorporate continuous type spaces and arbitrary distributions.[12]

In particular, consider the standard class of crisis bargaining games in which states can either negotiate a settlement or fight a war. As before, a settlement generates x as A's utility and $1-x$ as B's utility. Meanwhile, war generates $p(m_B+t)-c_A$ and $1-p(m_B+t)-c_B$, where m_B reflects B's type. Note that war payoffs are a function of type but settlement payoffs are not.

To incorporate uncertainty generally into the class of models, let $F(m_B) : [\underline{m}_B, \overline{m}_B] \mapsto [0,1]$ be the cumulative distribution function of B's types. B privately observes the draw whereas A only knows the prior distributions. I assume that $F(m_B)$ is differentiable everywhere on the interval and let $f(m_B)$ represent the associated density function.

[11] See Fey and Ramsay (2011) for a primer on mechanism design in militarized conflict.

[12] Another advantage of mechanism design is that the general result I describe below does not require an explicit solution to a particular extensive form. This is useful because even simple continuous type distributions with explicit but basic $p(m_t+t)$ functions quickly become intractable when solving for the first order condition, which still requires filtering the optimal offer back through the cumulative distribution function and taking a derivative on t to obtain the ultimate solution. For readers concerned that Proposition 1 is an artifact of the binary type space, note that the result holds regardless of how close or far apart $\underline{m}_B$ and $\overline{m}_B$ are. It therefore does not exploit a sufficiently large gap in the type space.

Following Banks (1990) and Fey and Ramsay (2011), I only look at games that satisfy the *voluntary agreements* axiom. Voluntary agreements requires that each player, through some unilateral set of strategies, can force the game into a war outcome. Games that do not follow this do not accurately reflect the anarchical nature of international relations—states cannot be forced into a peaceful settlement that makes them worse than if they were to just fight.

My primary interest is in how transfers affect the prospects for peace. I therefore use mechanism design to search for parameters that allow for *always peaceful equilibria*, defined as an equilibrium with 0 probability of war. The following shows that transfers help make such outcomes available:

Theorem 1. *If a game form with an always peaceful equilibrium exists without a transfer, then a game form with an always peaceful equilibrium still exists for any sized transfer. If no game form exists with an always peaceful equilibrium without a transfer, then a game form with an always peaceful equilibrium exists for a sufficiently large transfer.*

Roughly, Theorem 1 states that it is "easier" in some sense to achieve peace with larger transfers. The first part states that transfers cannot eliminate the existence of game forms with always peaceful equilibria. If the parties could negotiate in a way that ensures peace without a transfer, they can still do that with a transfer. The second part says that the result does not run the other way. If the states have to fight with some probability without a transfer, it is possible that the transfer solves the problem. The "sufficiently large transfer" part goes further. Flooding B with armaments at some point *must* allow for a game form that permits guaranteed peace.

The intuition has a similar flavor to the discrete type game analyzed previously. Incentive compatibility and voluntary agreements require that the concession given to B must be at least the value of the high type's war payoff. If not, the high type's voluntary agreements condition would be violated. Moreover, this concession must be equivalent across types, otherwise some type would have incentive to lie and thus violate incentive compatibility.

Meanwhile, A's voluntary agreements constraint requires that such a concession must still leave A at least as much as if it fights a war against all types. As t increases, diminishing marginal returns imply that the difference between the most powerful type and all other types decreases. Thus, weaker types behave more similarly to stronger types. In turn, the overpayment to weaker types becomes smaller. Eventually, A prefers the minimum amount necessary to buy compliance from all types to its war payoff against all types. At that point, game forms exist in which the equilibrium probability of war is 0.[13]

Figure 1 gives a blunter intuition. As the transfer becomes larger, the power difference of various types goes to 0. In essence, the game converges to a complete information interaction. Existing results (i.e., Fearon (1995)) establish that peaceful settlements exist under these circumstances. Theorem 1 states that transfers move the incentives in this direction, resulting in a mechanism that produces always peaceful outcomes.

One interesting characteristic of the theorem is that it requires no additional assumptions about the p function. All that is necessary are increasing benefits to arms and decreasing marginal returns. Even relatively flat p functions—those that are insensitive to transfers—still have a critical threshold. This may be surprising given Proposition 1's intuition that the mechanism works because transfers alter the probability of proliferation. However, recall from Figure 1 that the transfer induces peace precisely because it pushes the possible probabilities of victory onto a flatter portion of the function. Thus, functions that begin as flat are conducive to peace in general. The transfer only serves as an additional nudge.

To be clear, this result is *not* a comparative static. It simply gives conditions under which games exist that result in a peaceful equilibrium. However, an alternative pitch of the theorem is as follows. Imagine a world in which the costs of war are sufficiently low, a patron state supplies a protégé state with arms, and peace certainly prevails between the protégé and its opponent. If the patron were to cut its aid, then the probability of war *must* increase. It *cannot* remain at zero no matter the crisis bargaining game. The extra portion of the time war occurs is directly attributable to the absence of aid.

The proof for the theorem also characterizes the minimum transfer a patron state would have to donate to give rise to game forms with peaceful equilibria. In particular, the incentive compatibility and voluntary agreements constraints require

[13]That intuition only describes the necessary conditions for an always peaceful equilibrium. However, sufficiency is trivial: a game in which the players must mutually consent to a division x that fits the described constraints is such a game.

$$c_A + c_B \geq -\int_{\underline{m}_B}^{\overline{m}_B} \left(\frac{\partial}{\partial m_B} p(m_B + t) \right) F(m_B) dm_B \tag{2}$$

The proof in the appendix shows the right hand side strictly increases in t.[14] Thus, the minimum transfer necessary to create peaceful equilibria is the minimum t such that Condition 2 holds. Call that value t^*. Note that Condition 2 holds for $t = 0$, then $t^* = 0$. And per the theorem, game forms with peaceful equilibria would continue to exist if a third party issued a transfer anyway.

Further analysis of the condition echoes some of the earlier claims for the explicit game form. In particular, higher costs for either party require a smaller increase. Additionally, smaller transfers are necessary for a distribution that first-order stochastically dominates another distribution.[15] Substantively, this means that obtaining the desired game form is easier as the distribution puts greater weight on types with greater armaments.[16]

As a final note, Fey and Ramsay (2011) calculate the minimum peace subsidy necessary to obtain the desired game forms. Because peace subsidies essentially act as additional costs of war, including a subsidy s and rearranging Condition 2 shows that the minimum necessary subsidy is:

$$s^* = -\int_{\underline{m}_B}^{\overline{m}_B} \left(\frac{\partial}{\partial m_B} p(m_B + t) \right) F(m_B) dm_B - c_A - c_B$$

Thus, a third party only interested in peaceful outcomes—and agnostic about the distribution of the good implemented through war or peace—has an interesting option. It can push the game into parameters with peaceful equilibria either through offering s^* or t^*. Let $k(t)$ be a function that maps a transfer of weapons to a production cost k for the third party. Then, supposing that the always peaceful game form is played,

[14] Due to the leading negative on the right hand side, one might expect that if Condition 2 holds for all t. However, the integral is negative, thereby making the overall right hand side positive.

[15] One can see this by noting that $F_1(m_B)$ first order stochastically dominating $F_2(m_B)$ implies that $F_2(m_B) \leq F_1(m_B)$ for all m_B, with the inequality holding strictly somewhere. Changing the distribution does not alter the derivative, and so the magnitude of the corresponding shape that the interval measures is always larger for the dominated distribution. (The sign of the interval is negative, but this cancels with the leading negative term on the right hand side.) As a result, the right hand side is larger for the dominated distribution, making the inequality harder to fulfill for any given value of t.

[16] As before, higher chances of facing a better-armed opponent reduces the required overpayment to more poorly-armed types, thus incentivizing A to reach an agreement.

the third party prefers transfers to subsidies if $k(t) < s$. This generates the intuitive implication that countries with relatively advanced military production techniques will try to keep the peace with armaments, while opposite countries have to use subsidies instead.

4 Conclusion

How do arms transfers affect the prevalence of war? This paper showed that, under broad conditions, additional armaments promote peace when states face uncertainty over their opponents' military resources. Intuitively, the source of a state's uncertainty becomes increasingly irrelevant when the quantity of known transfers overwhelms whatever else could possibly exist. Screening offers look less attractive under these circumstances. As such, the offer the proposer picks is less likely to end in fighting.

I conclude with three comments. First, for researchers, this result underscores Fey and Ramsay's (2011) finding that the sources of uncertainty matter. Since Fearon (1995), scholars of international relations have become intimately familiar with the notion that uncertainty causes war. But common solutions to the problem remain vague and mostly recommend information provision.[17] This is despite the fact that the relationship between information and war is ambiguous—worried states that receive positive information can become overly optimistic and switch to making offers that generate some risk of war (Arena and Wolford, 2012). International relations as a field would benefit from more work that investigates how changing parameters manipulates incentives under specific sources of uncertainty. Put differently, "uncertainty" should not be treated as some uniform mechanism for war.

Second, the core mechanism also applies going in the opposite direction. That is, "negative" third-party transfers exacerbate an information problem between two states. For example, suppose an international intervention destroyed a government armory. Suppose further that potential revolutionaries were aware of this armory's existence and could also observe its destruction. Such an informational structure might suggest that the consequences of the mission on would give the revolutionaries more bargaining power and not have clear implications on the probability of war. However, my results

[17]For example, (Kydd, 2010, 104) writes that "if uncertainty leads to cooperation failure, then information can lead to conflict resolution."

show that this would incentivize riskier demands from the revolutionaries if they faced uncertainty about what other military resources the government might control. Future research could investigate this further and integrate the underlying theory with the broader literature on the perverse incentives of interventions (Kuperman, 2008).

Finally, for policymakers, my results combined with Benson, Meirowitz and Ramsay's (2016) urges caution in crafting broad strategies to manipulate worldwide rates of conflict. Single strategies—like military transfers—may work in some cases, like with uncertainty over existing allotments. Given the literature's stance on uncertainty in intrastate disputes (Walter, 1999; Fearon, 2007), potential civil wars seem to be a likely application. But they might backfire in other cases. As such, crafting quality policies requires the adoption of specific approaches on a case-by-case basis. Broad solutions may be ideal, but they simply do not have general theoretical support.

5 Appendix

Here, I prove the mechanism design results and investigate how transfers influence uncertainty over martial effectiveness.

5.1 Proof of Theorem 1

Proving the theorem requires considering B's voluntary agreements and incentive compatibility constraints and A's voluntary agreements constraint. First, consider B's incentives. Voluntary agreements requires that each type receive at least its war payoff for participating in the mechanism. In particular, the $\overline{m}_B$ type must receive at least $1 - p(\overline{m}_B + t) - c_B$. This is the largest of the individual constraints.

Incentive compatibility also requires that no type wish to falsely report a different type. An always peaceful mechanism can only induce this behavior through the settlement quantity $1-x$. Because settlement payoffs are *not* a function of type, this implies that all types must receive the same settlement value—otherwise a type would want to deviate to reporting a type that received a larger settlement value. Recalling that the $\overline{m}_B$ type must receive at least $1 - p(\overline{m}_B + t) - c_B$, *all* types must receive that amount. This generates the first constraint on x:

$$1 - x \geq 1 - p(\overline{m}_B + t) - c_B$$

$$x \leq p(\overline{m}_B + t) + c_B \tag{3}$$

Now consider A's voluntary agreements constraint. To participate in the mechanism, A must receive at least its value for fighting a war against all types. This generates the second constraint on x:

$$x \geq \int_{\underline{m}_B}^{\overline{m}_B} p(m_B + t) f(m_B) dm_B - c_A \tag{4}$$

For a mechanism to exist, Conditions 3 and 4 must hold simultaneously. This is only possible if:

$$p(\overline{m}_B + t) + c_B \geq \int_{\underline{m}_B}^{\overline{m}_B} p(m_B + t) f(m_B) dm_B - c_A$$

Using integration by parts, I can rewrite this as:

$$p(\overline{m}_B + t) + c_B \geq p(\overline{m}_B + t) - \int_{\underline{m}_B}^{\overline{m}_B} \left(\frac{\partial}{\partial m_B} p(m_B + t) \right) F(m_B) dm_B - c_A$$

$$c_A + c_B \geq - \int_{\underline{m}_B}^{\overline{m}_B} \left(\frac{\partial}{\partial m_B} p(m_B + t) \right) F(m_B) dm_B \tag{5}$$

I am interested in how the right hand side changes as a function of t. Specifically, if the right hand side of Condition 5 decreases in t, then increasing transfers makes the existence of game forms with peaceful equilibria easier:

$$\frac{\partial}{\partial t} \left(- \int_{\underline{m}_B}^{\overline{m}_B} \left(\frac{\partial}{\partial m_B} p(m_B + t) \right) F(m_B) dm_B \right) < 0$$

Differentiating under the integral yields:

$$\int_{\underline{m}_B}^{\overline{m}_B} \left(\frac{\partial^2}{\partial m_B \partial t} p(m_B + t) \right) F(m_B) dm_B > 0$$

The cross partial of $p(m_B + t)$ is strictly positive, and so too is $F(m_B)$. The product of the two is therefore strictly positive. The left hand side takes the integral of a function that is strictly positive, implying that the result is strictly positive. Thus, the condition holds.

This shows that increasing t can only expand the parameters for which a game form with an always peaceful equilibrium exists. It does not demonstrate that a sufficiently large value of t guarantees a game form with an always peaceful equilibrium. To do this, consider again the right hand side of Condition 5. If this goes to 0 as t goes to infinity, then the always-positive left hand side must be greater than it for some t.

I can demonstrate this by showing that $\frac{\partial}{\partial m_B} p(m_B + t)$ goes to 0 as t goes to infinity. This is because the right hand side takes the area under the curve of $\frac{\partial}{\partial m_B} p(m_B + t)$ and $F(m_B)$ on the finite interval $\underline{m}_B$ to $\overline{m}_B$. $F(m_B)$ is constant in t and constrained between 0 and 1. Thus, if $\frac{\partial}{\partial m_B} p(m_B + t)$ goes to 0 as t goes to infinity, so to must the right hand side.

For proof by contradiction, suppose it does not. Then the slope of the curve remains fixed below some value $-\epsilon$ for all values of t, where $\epsilon > 0$.[18] But then for any $t > \frac{1}{\epsilon}$, the output of $p(m_B + t)$ must decrease by at least 1. This is not possible for a function strictly bounded between 0 and 1, a contradiction. □

5.2 Proof of Uncertainty over Martial Effectiveness

I now show that the result applies to uncertainty over military resources and not uncertainty over p more generally. Borrowing from Arena's (2013) setup, suppose that A's probability of victory is now $p(\alpha(m_B + t))$, where $\alpha \geq 0$ captures martial effectiveness; larger values of α indicate that B can better wield each unit of its military armaments. Intuitively, $p(\alpha(m_B + t))$ is strictly decreasing in α; that is, A wins less often when B's effectiveness is larger. Unlike before, A is certain about m_B. Instead, A is unsure whether B's martial effectiveness is $\underline{\alpha}$ or $\overline{\alpha}$, where $\overline{\alpha} > \underline{\alpha}$.

The core mechanics of the game remain the same, rewriting earlier probabilities of victory as $p(\underline{\alpha}(m_B + t))$ and $p(\overline{\alpha}(m_B + t))$. A's two possible optimal demands are $p(\underline{\alpha}(m_B + t)) + c_B$ and $p(\overline{\alpha}(m_B + t)) + c_B$. The riskier offer is preferable when:

[18]The slope is negative because $p(m_B, t)$ is decreasing. It must remain below that point because the second derivative is positive, so that all slopes before a point must be less (that is, more sharply downhill) than the current slope.

$$q > \frac{c_A + c_B}{p(\underline{\alpha}(m_B + t)) - p(\overline{\alpha}(m_B + t)) + c_A + c_B}$$

Recall that the circumstances for war decrease when the cutpoint increases. Taking the derivative of the right hand side with respect to t and checking when it is positive yields:

$$\frac{(c_A + c_B)\left(\frac{\partial}{\partial t}(p(\overline{\alpha}(m_B + t)) - p(\underline{\alpha}(m_B + t)))\right)}{(p(\underline{\alpha}(m_B + t)) - p(\overline{\alpha}(m_B + t)) + c_A + c_B)^2} > 0$$

$$\frac{\partial}{\partial t}(p(\overline{\alpha}(m_B + t))) > \frac{\partial}{\partial t}(p(\underline{\alpha}(m_B + t)))$$

Applying the chain rule generates:

$$\overline{\alpha}\left(\frac{\partial}{\partial t}p(\overline{\alpha}(m_B + t))\right) > \underline{\alpha}\left(\frac{\partial}{\partial t}p(\underline{\alpha}(m_B + t))\right)$$

Recall that $\overline{\alpha} > \underline{\alpha}$. However, because giving B armaments decreases A's probability of victory, both derivatives are negative. And due to diminishing marginal returns, $\frac{\partial}{\partial t}p(\overline{\alpha}(m_B + t)) > \frac{\partial}{\partial t}p(\underline{\alpha}(m_B + t))$. Taking stock, the left hand side consists of a large positive number multiplied by a negative number with a small magnitude; the right hand side consists of a small positive number multiplied by a negative number with a large magnitude. As such, the effect of transfers varies—it depends on the specific functional forms, the baseline level of B's armaments, and the exact quantity of transfers.

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