ANARCHY[1]

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Relations between states are often characterized as anarchic, in the sense that there is no ultimate authority regulating these relations. Especially in the realist and neorealist traditions of International Relations thought, states are viewed as purposive actors with material interests and objectives; their interactions under anarchy would thus appear amenable to the formal modeling typically pursued by economists and other social scientists who follow a rational-choice approach. Up to relatively recently, though, there had been surprisingly little such work on formally modeling anarchy in general, and there is still even less work on modeling anarchy in International Relations specifically. This could be partly explained by the rooting of neoclassical economics on the liberal tradition of thought that assumes away anarchy, any imperfections in contracting, or the costly enforcement of property rights. For example, all received models of international trade abstract away from security considerations and thus the possible connections between trade and security policies cannot even be considered within such models.

In this chapter I will introduce recent research from economics that models anarchy. Although relations between states are not its main concern, this research clearly has implications for thinking about inter-state relations and there are indications that such relations are becoming a greater as well as a fruitful concern. The starting point of the approach is that under anarchy parties cannot write enforceable contracts that would eliminate arming and the possibility of using violence. That starting point goes against a long tradition of neoclassical economics that assumes property rights are perfectly and costlessly enforced but it is consistent with the more basic assumption of self-interest, for a genuine *Homo Economicus* would not be restrained from using force if using force were to enhance his material interests.

To enhance accessibility, I will present only simplified versions of models and only discuss the intuition of many results. The reader who is interested in more detail is referred to the particular items in the references. Questions that will

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be discussed include: How is power under anarchy determined and distributed? What are some of the determinants of open conflict versus settlement under the threat of conflict? How can trade and security policies be related? How do norms and institutions of governance affect the outcome under anarchy? What kind of governance can be expected to emerge out of anarchy? Obviously, some of these are fundamental questions of social science – not just of political science or economics – and it would be presumptuous to assume the literature reviewed here provides new answers. Nevertheless, the hope is that this formal modeling approach reframes such old questions in ways that can help clarify the nature of the different possible answers that have been offered in the past.

1 The Basics: Guns vs. Butter

Under anarchy there is no higher authority – laws, courts, police – to enforce contracts externally. Any contracts made by individual parties have to be enforced by the parties themselves. As with contracts enforced by the state, the ultimate power to do so comes out of the threat of using force. Norms, informal and formal agreements, whatever international laws and institutions might exist could well restrain and shape the use of force, but the extent of a party's capability with guns can be reasonably considered the most important determinant in the party getting better terms under anarchy. While guns can enhance one party's position relative to others, they are expensive to produce and reduce material welfare in other ways. Thus, in examining interaction under anarchy, the basic trade-off between guns and butter is central.

Over the past few decades, Jack Hirshleifer was the first economist to argue that, in making a living, there is a basic trade-off between production and appropriation - between producing and taking away the production of others or between guns and butter. The basic approach presented here follows Hirshleifer and related contributions.[2] To organize my discussion, I will present a basic model of anarchy. For now, suppose there are just two countries, labelled 1 and 2. Each country $i = 1, 2$ has a total amount of resources R_i that can be considered a composite of its labor, capital, land and other inputs that can be used in producing guns and butters. In particular, the basic trade-off between the production of guns (G_i) and butter (B_i) is given by the following constraint:

$$R_i = G_i + \frac{1}{\beta_i} B_i \tag{1}$$

[2] Hirsheifer (1988) was the first paper to allow for that trade-off. Hirshleifer's other work in the are includes Hirshleifer (1989, 1990, 1995) and the collection of his articles in Hirshleifer (2001). Haavelmo (1954) has the first model in which production and appropriation are allowed. Other contributors to the more recent literature include Garfinkel (1990), Grossman (1991), Skaperdas (1992), Grossman and Kim (1996), Esteban and Ray (1999), Wittman (2000), and Mehlum et. al. (2000). Hirshleifer (1994) provides an argument for importance of the approach in general, whereas Skaperdas (2003) is a critical review of the literature. A special issue of the Journal of Conflict Resolution included some relevant papers (Sandler, 2000, has the overview).

where $\beta_i > 0$ is a productivity parameter for country i. Given this constraint, for any given choice of guns, country i's production of butter would equal

$$B_i = \beta_i(R_i - G_i) \tag{2}$$

From this equality it is clear that a country's production of butter would be higher, (i) the lower is its production of guns, G_i; (ii) the higher is the country's resource, R_i; and (iii) the higher is its productivity, β_i.

We suppose that each country and its population materially value what they can directly consume, which in this benchmark model is butter and not guns. In a world with perfectly secure property rights – the opposite extreme to anarchy – each country would therefore have no need for guns and could devote all of its resources to the production of butter and consume all of that production. Under anarchy, though, the butter a country were to produce would not be secure and some or all of it could be subject to capture by the other country in the event of conflict or be extorted away under the threat of it. Likewise, the country could decide that it is more profitable to go after the other country's butter rather than produce much butter. Guns, not butter, is the currency that ultimately counts under this ideal type of anarchy. Then, before considering how the countries would allocate their resources between guns and butter, we need to establish how exactly the currency of guns is cashed in.

Technologies of Conflict

Guns affect the chances that each country has in prevailing if conflict were to occur. Then, given a choice of guns by the two countries, G_1 and G_2, we can denote the probability of country 1 winning as $p_1(G_1,G_2)$ and the probability of country 2 winning as $p_2(G_1,G_2)$. Clearly, the probability of each country winning can be expected to be higher, the higher is its own quantity of guns and the lower is the quantity of guns of its opponent. How these expenditures on guns affect the winning probabilities of each party depend on the state of the military technology. With both countries having access to the same military technology, a reasonable property for the winning probabilities is to have $p_1(G_1,G_2) = p_2(G_2,G_1)$. A wide class of functional forms that has been examined is the following:

$$p_1(G_1, G_2) = \frac{f(G_1)}{f(G_1) + f(G_2)} \tag{3}$$

provided G_1 or G_2 is positive (otherwise, $p_1(G_1, G_2) = 1/2$) and where$f(.)$ is a non-negative, increasing function.[3] The most commonly used functional form is the one in which $f(G_i) = G_i^m$, where $m > 0$ (and often, for technical reasons, $1 \geq m$), so that

$$p_1(G_1, G_2) = \frac{G_1^m}{G_1^m + G_2^m} \tag{4}$$

[3]. A major property of this class of functional forms is the "independence from irrelevant alternatives" property, whereby the probability of winning of either side does not depend on the guns possessed by third parties to the conflict. Hirshleifer, 1989, has examined two important functional forms and Skaperdas, 1996, has axiomatized the class.

For this form the probability of winning depends on the ratio of guns expenditures by the two parties. Some effects of different military technologies can be captured by the parameter m; for example, the technology of seventeenth century warfare during the thirty years war, with its large armies and artillery units, can be thought of as having a higher value for this parameter than the feudal levies of Medieval Europe. Such factors have consequences for the size of political units.

How Power is Determined

We can now examine how the two countries can be expected to distribute their resources between guns and butter in this simple setting. We abstract away from all the collective action problems as well as those of strategic interaction between domestic political groups and suppose that each country behaves as a unitary actor. With both countries caring about how much butter they will consume and supposing that they are risk neutral,[4] the expected payoffs in the event of war, in which the winner receives all the butter and the loser receives nothing, would be the following:

$$W_1(G_1, G_2) = p_1(G_1, G_2)(B_1 + B_2) = p_1(G_1, G_2)[\beta_1(R_1 - G_1) + \beta_2(R_2 - G_2)]$$
$$W_2(G_1, G_2) = p_2(G_1, G_2)(B_1 + B_2) = p_2(G_1, G_2)[\beta_1(R_1 - G_1) + \beta_2(R_2 - G_2)] \quad (5)$$

Note that these two payoffs are thought of as depending on the expenditures on guns by the two parties, since given (2) the choice of guns by each party determines the quantity of butter as well. Furthermore, because these payoffs are derived on the condition that the two countries are risk neutral, the probability of winning for each country, $p_1(G_1, G_2)$ and $p_2(G_1, G_2)$, can also be interpreted as the share of total butter each country receives in the shadow of war.

We are interested in deriving Nash equilibrium strategies for guns – that is, a combination (G_1^*, G_2^*) such that $W_1(G_1^*, G_2^*) \geq W_1(G_1, G_2^*)$ for all G_1 and $W_2(G_1^*, G_2^*) \geq W_2(G_1^*, G_2)$ for all G_2. At a Nash equilibrium there is no incentive for any party to deviate in their strategies. At that equilibrium the marginal benefit of each country's choice of guns equals its marginal cost so that

$$\frac{\partial p_1(G_1^*, G_2^*)}{\partial G_1}(B_1^* + B_2^*) = p_1(G_1^*, G_2^*)\beta_1$$
$$\frac{\partial p_2(G_1^*, G_2^*)}{\partial G_2}(B_1^* + B_2^*) = p_2(G_1^*, G_2^*)\beta_2 \quad (6)$$

The marginal benefits in the right-hand side include the total butter that is contested multiplied by the marginal increase in the probability of winning. The marginal cost includes the probability of winning times the productivity parameter of each country. That is, the higher is the productivity of a country (in the production of butter), the higher is its marginal cost of producing guns.

[4] Under risk neutrality there is neither aversion towards risk nor love of risk. Clearly, this is a strong assumption that is nevertheless analytically very convenient that is almost always adopted when a certain problem is first modelled. We discuss the effects of risk aversion in section 2.

Therefore, the more usefully productive country has an incentive to produce fewer guns whereas to less usefully productive country has an incentive to produce more guns. That is, the less usefully productive party has a comparative advantage in gun production.

In fact, in this specific model it can be shown that, as long as both countries produce some butter, the country with lower productivity will produce more guns (i.e., $G_1^* < G_2^*$ if and only if $\beta_1 > \beta_2$). The less productive country would then have a higher probability of winning or, if the countries were to settle in the shadow of conflict, a bigger share of the total amount of butter. In the latter case, typically the more productive country would provide tribute in butter to the less productive and more powerful one.[5] There are numerous historical examples in which marcher states or tribal federations, characterized by low productivity, have subjugated more productive and established states. Central Asia, for instance, has been the breeding ground for successive invasions and conquests, all the ways from the Western and Eastern Roman empires, to states in the Middle East, to India, China, and even Japan. The Arab twelfth-century philosoper-historian Ibn Khaldun (1967) even built a theory of the cycles of history based on successive waves of barbarians, with little useful productivity other than being good at warfare, conquering settled, productive areas and then, after they themselves become civilized and soft, are conquered by a fresh wave of uncouth warriors from the steppes.

We should not, however, take this result that productivity and power are always inversely related literally both because it does not always hold formally and because empirically there are cases in which those who are more usefully productive can also be more powerful. Formally, if we were to allow a more general production function for butter than we have done in (2), the less productive country would not be necessarily more powerful. Nevertheless, there would be a strong tendency for improvements in productivity leading to less power, in the sense that a higher β_i would lead to a lower probability of winning or share for country i ($p_i(G_1^*, G_2^*)$).[6]

In related work that examines the dynamic incentives for innovation, Gonzalez (2003) has found a range of conditions under which butter consumption would be reduced if a country were to adopt a superior technology (i.e. one with a higher β_i). Under such conditions, superior technologies available at zero cost would not be adopted because they would confer a disadvantage to those who adopt it, an outcome that Gonzalez argues as relevant to many instances of slow adoption or the outright rejection of superior technologies in history.

One curious result of the interaction described by (3) is that the initial resources can be shown to have minimal effect on power. For example, under the conflict technology in (4) the ratio of guns of the two countries depends only on the ratio of productivities and on the parameter m (in particular, we have $G_1^* = (\beta_2/\beta_1)^{\frac{1}{m+1}} G_2^*$), as long as these expenditures on guns are lower than

[5] The only exception to this outcome is when the resource of the more productive country is not too much smaller than the resource of the less productive country.

[6] Skaperdas and Syropoulos (1997) describe general conditions under which this outcome occurs.

the resources of each country. Nevertheless, this result does not generalize when there is risk aversion or when there is complementarity in consumption or production so that, for instance, the two countries produce different types of outputs. In any of those more general settings and under a wide set of conditions, a higher level of resource R_i would lead to more power for country i (Skaperdas and Syropoulos, 1997, derive such results).

Finally, in discussing this simple benchmark model of anarchy, higher levels of the "effectiveness" parameter m in the conflict technology (4) always lead to higher levels of guns and thus lower production of butter and material welfare. In the remainder of this chapter we will discuss additional questions that can explored using the approach just introduced.

2 Settlement in the Shadow of Conflict

The "power" of each country i, $p_i(G_1^*, G_2^*)$, has been interpreted as either a probability of winning in the event of conflict or as a share of total output in the shadow conflict. That equivalence has been derived under the assumption of risk neutrality as well as other conditions that we will shortly mention. In practice, interactions under anarchy typically involve a great degree of accommodation by the interacting parties with warfare being only a last resort, and the outcomes under conflict and under settlement are rather different. When, then, will there be a negotiated settlement (a "cold" war) and when conflict (a "hot" war)? First, in order to be clear, we will consider the following protocol of moves:

> 1. The two countries choose their respective levels of guns and butter.
>
> 2. The two countries negotiate in the shadow of conflict about how to divide the total butter available for division. If they agree on a division, the division takes place and each country consumes its share.
>
> 3. In the event of no peaceful division, conflict takes place with one side winning the whole available quantity of butter.

The decision whether to go to war is taken at stage 2. Obviously, both sides would have to agree on a negotiated settlement but just one side can make the decision to have war. There are a number of compelling reasons that both sides would prefer a settlement at stage 2 and we list some major one below.

1. War is destructive

Contrary to our implicit assumption in the previous section, in which we assumed that war does not destroy any of the butter produced by the two countries, war is typically destructive in output, resources, and the use of arms beyond those that would be necessary for a negotiated settlement. In the absence of other benefits to war then, it appears that a negotiated settlement would be feasible, provided of course that the two sides have open channels of communication.

To illustrate the possibilities for a negotiated settlement, consider any particular choice of guns that might have been made in stage 1, say (G_1', G_2') with associated choices of butters (B_1', B_2'). Furthermore, suppose that if war were to occur, only a fraction $\phi(< 1)$ of total butter would be left for the winner with the remainder fraction, $1 - \phi$, destroyed during war. Then, the expected payoff in the event of war for country i would be $p_i(G_1', G_2')\phi(B_1' + B_2')$. Then, consider the possibility of peacefully dividing the total quantity of butter according to the winning probabilities. Then, under risk neutrality the (deterministic) payoff for country i would be $p_i(G_1', G_2')(B_1' + B_2')$ which, given that $\phi < 1$, is strictly higher than the expected payoff under war. Thus, both sides would have an incentive to agree on the division of the total pie in accordance with the winning probabilities. There are also other possible ways of dividing the pie – an issue that can lead to other problems associated with the bargaining problem. However, the threat of war limits the number of possible settlements acceptable to both parties and the threat of war provides an enforcement device for whatever settlement that the parties may arrive at.

2. Risk aversion and the uncertainty of war's outcome

As we have modelled it and as it is in practice, the outcome of war is typically uncertain. Thus far, we have maintained that the two sides are risk-neutral – that they do not care about the risk entailed in the outcome of war. However, when it comes to big uncertain outcomes that affect people's jobs, careers, health, and lives, most people are risk averse – they do not like taking big risks and, if they face them and insurance is available, they will insure against them. That risk aversion can be expected to transfer to political and military leaders and to the risk preferences expressed at the country level. Because war is uncertain but a particular settlement is not, a range of negotiated settlements can be expected to be preferable by both parties.

Again, to illustrate the basic point, suppose particular choices have been made for guns, (G_1', G_2'), and butter, (B_1', B_2'), at stage 1. Under risk aversion, suppose both countries have strictly concave von-Neumann-Morgenstern utility functions $U(.)$. Then, the expected payoff in the event of war for country i is $p_i(G_1', G_2')U(B_1' + B_2') + (1 - p_i(G_1', G_2')U(0)$. (The second term reflects is the expected payoff in the event of losing the war.) On the other hand, the payoff under a negotiated settlement in which each party receives a share of butter that equals its winning probability would be $U[p_i(G_1', G_2')(B_1' + B_2')] = U[p_i(G_1', G_2')(B_1' + B_2') + (1 - p_i(G_1', G_2')0]$, which by the strict concavity of $U(.)$ is strictly greater than the expected payoff under war. Thus, both sides would strictly prefer to divide the pie according to their winning probabilities than going to war. Again, a range of other divisions of the pie would be preferable by the two sides over going to war.

The modeling approach we have followed has one source of uncertainty – who will win and who will lose – that, moreover, is expressed by probabilities that are common knowledge to both sides. That is a lot of knowledge to possess and in its absence there would be additional sources of uncertainty: different expectations, unforeseen contingencies, and so on. The presence of such additional sources of uncertainty in the presence of risk aversion would normally make the two sides

be more conservative and more willing to negotiate. However, this does not always need to be the case for two reasons: First, we simply have not examined the effect of risk aversion in such more complicated environments formally in order to confirm the conjecture. And, second, in the presence of incomplete information whereby each side has different beliefs about the nature of their interaction, the choice of war can actually be an equilibrium as it is well-known from an extensive literature (see, e.g., Brito and Intriligator, 1985, or Bester and Warneryd, 2000).

3. Complementarities in Production or Consumption

Another consequence of wars having winners and losers is that the goods with which each side ends up could easily be far from what would be optimal for production or consumption. In the case of war over territory, the winner could get all the contested land minus its people who might become refugees on the loser's remaining territory. Then, it is highly likely that the winner would have too much land relative to the labor that it has available whereas the loser would have too little land relative to its available labor. A negotiated settlement could avoid this imbalance and make both sides better off than they would be in expected terms under war. As there is complementarity between factors of production, so there is between final consumption goods and a similar argument can be made in favor of negotiated settlements when there are such complementarities in consumption.

In order to take account of complementarities formally, the benchmark model would have to be enriched. One possibility is to have final production or consumption being a function $F(B, L)$ where B is butter and L is another good that is non-appropriable, and the function is increasing and has diminishing returns in both of its arguments. Suppose each side has an endowment of L_i and, again, consider that in stage 1 they have chosen a certain quantity of guns, (G'_1, G'_2), and butter, (B'_1, B'_2). Then, the expected payoff of country i under war would be $p_i(G'_1, G'_2)F(B'_1 + B'_2, L_i) + (1 - p_i(G'_1, G'_2)F(0, L_i)$. Under a negotiated settlement with each country receiving a share of butter equal to its winning probability, the payoff would be $F[p_i(G'_1, G'_2)(B'_1 + B'_2), L_i]$, which by the property of diminishing returns is butter can be shown to be strictly higher than the war payoff. Thus, a negotiated settlement is again superior to war for any given choice of guns and butter.

How Much Arming ? Settlement Under Different Rules of Division

We have shown a wide range of variations of the benchmark model that make a negotiated settlement in stage 2 always better for both sides. That is, settlement is part of any perfect equilibrium of games with the protocol of moves that we specified above. We have not touched upon, though, the issue of arming under settlement. Since the two countries can not make firm commitments on arming, any settlement they arrive at depends on the relative amount of guns the two sides possess. Does the fact that the countries can be expected to reach a negotiated settlement reduce their arming compared to the case of war? Given that there are many possible negotiated settlements and rules of division, which ones would the two sides be expected to use? Are there any rules of division

that are better than others and in what sense?

The answer to the first question is "not in general," and answering it is related to the other two questions just posed. For how many guns (and how much butter) the two sides decide to produce in stage 1 critically depends on the rule of division they expect to follow in stage 2, the stage of negotiations.

To illustrate some possibilities consider a model that allows for destructive war. In particular, suppose that a resource of total T is contested by the two sides and side i pays a cost of guns of G_i regardless of whether they win, lose, or settle. In the case of war a fraction $1-\phi$ of T is lost. In addition, suppose that in stage 2 the contested resource is divided in accordance with the winning probabilities; that is, country i receives the share $p_i(G_1, G_2)$.

Then, the payoff function under war would be: $p_i(G_1, G_2)\phi T - G_i$. The payoff function under settlement would be $p_i(G_1, G_2)T - G_i$. For simplicity, let $m = 1$. Then, the equilibrium guns under war would be the same for both sides and equal to $G^w = \frac{\phi}{4}T$ which, given that $\phi < 1$, is less than $\frac{1}{4}T$. Guns under settlement would also be the same for both sides and equal to $G^s = \frac{1}{4}T > \frac{\phi}{4}T = G^w$. That is, in this case *arming under settlement is higher than arming under war.* The total "pie" under settlement is higher than that under war because of the destruction brought about by war, whereas the way the two pies are divided are the same. The two sides just jockey for a better bargaining position under settlement by allocating more resources in guns than under war. It should be noted however that, even though more guns are produced under settlement, both sides receive higher payoffs under settlement than they have expected payoff under war, as the higher costs of arming under settlement are lower than the lost part of the contested resource in the case of war.

The division of the pie according to the winning probabilities is only one possible rule of division. In fact, this rule is not consistent with any of the bargaining solutions and non-cooperative bargaining games that have been extensively analyzed in the economic theory literature (see Muthoo, 1999). And, for the benchmark model with destruction, all symmetric bargaining solutions[7] would lead to the following share for country i: $\phi p_i(G_1, G_2)$+(1-ϕ)$\frac{1}{2}$. Note that according to this rule the more destructive is conflict (i.e., the higher is ϕ), the less guns matter in negotiated settlement. Actually, the equilibrium guns under this rule of division is the same as those under war noted in the previous paragraph ($G^w = \frac{\phi}{4}T$). With this rule, then, guns under settlement and under war are the same.

This example illustrates that *different rules of division lead to different levels of arming*. And the differences across different rules can be rather dramatic. For more general classes of problems, different bargaining solutions do not coincide as they do in the benchmark model. As Anbarci et. al. (2002) have shown, a number of bargaining solutions themselves can be ranked in terms of the amount of arming they induce and in terms of material efficiency, with those that put less weight to the threat utilities (which are the payoffs of going to war)

[7] These include the best known ones like the Nash solution and the Kalai-Smorodinsky. This outcome is also implemented by a number of alternating-offers noncooparative games (Mutthoo, 1999).

inducing less arming. Thus, *norms against threats* that are enshrined in international law, international institutions, or simply in the culture of interactions among states *can have real effects on arming and material welfare* without fundamentally changing the relative positions of states. That is, anarchy far from necessarily leading to just one outcome can lead to widely differing sets of outcomes, depending on the underlying norms of conduct by the states. Despite the absence of ultimate authority and enforcement, anarchy can be governed with norms and institutions that can provide different measures of commitment towards arming. While arming can not be expected to disappear, it can be largely supplanted by diplomacy and politics. Even if ultimately arming might have the final say in the event everything else were to fail, to sustain such a shift to politics requires wide recognition of the norms, institutions, and organizations as relevant to settling disputes.

The analysis we have followed thus far has been static or, equivalently, a steady state of a long-run process without any feedback through time. Over the past few decades the evolution of norms, institutions, and organizations has been modelled in much of rational-choice social science as implementing cooperative equilibria of indefinitely repeated supergames, with the "shadow of the future" (Axelrod, 1984) being of prime importance. That is, the more different participants value the future, the greater are the sets of superior alternatives to war that could be self-enforcing. Such an approach could provide a rationale for the adoption of different norms that bring about fewer guns and more butter under anarchy. A longer shadow of the future, however, can well make the more conflictual equilibria even worse, as Powell (1993) and Skaperdas and Syropoulos (1996) have demonstrated in different settings. In fact, a longer shadow of the future may well have the opposite effect in encouraging not just costlier negotiated settlements but also outright warfare, a topic to which we now turn.

3 Conflict and the Role of the Future

Given all the reasons in favor of negotiated settlement and coexistence of rival states, why are there wars at all? Incomplete and asymmetric information, as we have already mentioned, as well as simple misperceptions and the difficulties in attaining common knowledge of the relevant game that is being played (see Chwe, 2000) have been extensively analyzed over the past two decades as major sources of war. Typically these are the main reasons given for the occurrence of wars. In addition to those, however, Fearon (1995) has discussed an additional class of reasons that he identifies as the inability of different sides to make credible commitments.

In particular, within the models we have examined, each state is unable to commit to a certain level of arming. Negotiated settlements take place only with the backing up of each party's guns. But because the settings that we have examined are static, we have not allowed for the possibility of war altering the conditions for future interactions, of altering the balance of power between adversaries well into the future. Then, by pursuing war now, one party could

weaken its adversaries permanently or even possibly eliminate them and take control well into the future. Therefore, a party that values the future highly could indeed take the chance of war instead of pursuing negotiation and compromise, despite the short-term benefits of compromise, because the expected long-run profits could be higher in case the opponents become permanently weakened or eliminated. In environments in which those who win gain an advantage in the future, both the intensity of conflict and the choice of overt conflict over negotiation becomes more common (Garfinkel and Skaperdas, 2000) as the future becomes more important.

To illustrate how this argument goes through consider the following simple example. Suppose there are two states and they care about what happens *today* and about what happens in the $future$; that is, for simplicity, we can think of the game as having two periods. In each period there is total butter of 100 units. Because of incomplete contracting on arming, each side has to devote 20 units of resources to guns in each period. Given the guns they have there are two options, war and settlement. If they were to settle, each side would receive half of the butter for a net payoff of 30 units ($\frac{1}{2}100-20$). If they were to engage in war, each adversary would have half a chance of winning and half a chance of losing all the butter, which would however be reduced by 20 units as a result of the destruction that war would bring. The expected payoff of each side under war in a particular period would then be $\frac{1}{2}(100-20-20)+\frac{1}{2}(0-20)=20$. Therefore, because war is destructive both sides would have the short-term incentive to settle. War, however, has long-term effects on the relative power of the adversaries. For simplicity and starkness suppose that if there were war *today*, the loser would be eliminated and the winner could enjoy all the surplus by itself in the $future$ and do that without having to incur the cost of arming. Letting $\delta \in (0,1)$ denote the discount factor for the $future$, the expected payoff from compromise as of *today* - which would also imply settlement in the $future$ - would be $30+\delta 30$. The expected payoff from war, again as of *today*, would be $20+\delta(\frac{1}{2}100+\frac{1}{2}0)=20+\delta 50$. Thus, war would be preferable to settlement by both adversaries if $20+\delta 50 > 30+\delta 30$ or if (and only if) $\delta > \frac{1}{2}$. That is, war would be induced if the "shadow of the future" were long enough, whereas settlement and peace would ensue only if the future were not valued highly.

Wars of conquest, including those of Xerxes, Alexander the Great, of Roman Senators and Emperors, of the various Central Asian federations, of Medieval lords and potentates, of Absolutist European monarchs, of the Hapsburgs, Napoleon, Hitler, and many others could well be accounted by the combination of the inability to make long-term treaties that reduce arming and a long shadow of the future on the part of these rulers. They were calculated gambles that, if they turned out well initially, they could lead to a bandwagon effect of greater power. Although we tend to know more about the winners of such gambles, because they are the ones who are more prominent in the historical record, that record is also strewn with a lot more less successful individuals as well as states who have been on the losing side of these gambles. Asymmetry of information, of course, is present in one form or another and could account for cases in which a tribute was not agreed and instead a battle had to take place, but overall the

inability to commit along with a long shadow of the future is, I think, a very underrated source of conflict and its persistence.

4 Other topics in brief and future prospects

Because of space limitations we will now briefly refer to some important topics that have been examined thus far, as well as discuss possible fruitful directions that such research could take.

Alliance formation

States have rarely viewed all other states the same way. They are usually allied with some and not with others. What are the determinants of alliance formation? Is there a tendency for bipolarity (i.e., have two grand alliances) or not? The approach reviewed in this chapter could be promising in trying to answer such questions, and there have been some initial attempts in such a direction.

In studying the problem, there are two critical modeling issues that need to be confronted. First, once an alliance has formed, how do members of the alliance divide the total pie? In particular, does relative arming determine at all members' shares and how are these shares determined otherwise? Thus, Bloch et. al. (2002) suppose members of the alliance do not use arms at all in determining shares whereas Skaperdas (1996) analyzes the case in which shares are determined through arming. Second, there is no unique concept of equilibrium of different alliance structures (comparable, say, to Nash equilibrium) and, when there is, there can be more than one alliance structure that would be predicted (Ray and Vohra, 1999). Perhaps, as can be expected given these issues, there are no universal predictions about how alliances form or about bipolarity. Bloch et. al. (2002), with restrictions on the possible stability of alliances that favor the formation of large coalitions, predict the grand alliance; Skaperdas (1996) who analyzes the case of three countries finds a critical role for the technology of conflict in determining whether any alliances form; and Garfinkel (2004), who employees a solution concept that is not as advantageous to large coalitions, finds a number of different plausible outcomes other than the grand alliance.[8]

The multiplicity of possible outcomes suggests a critical role for history and path dependence, something that has not been incorporated in current models, primarily because the problem of alliance formation is computationally rather complex already in static settings. Clever ways of introducing dynamics could thus yield new insights into this important problem.

Trade openness and insecurity

From a classical liberal perspective – which by default is the perspective of neoclassical economics as well – international trade alleviates the problems with anarchy and is enough of a carrot to bring together potential adversaries. From a realist perspective, though, trade openness with adversaries can be anathema,

[8] Sandler and Hartley (1999) survey the literature on burden-sharing in already established alliances.

especially when the "relative" gains from trade go to the adversary. Conventional models of international trade assume all resources and trade itself are perfectly enforceable without leaving any room for arming and conflict, whereas our benchmark model allows for arming and conflict but not for trade. In order to examine the validity of the claims made by classical liberals and realists, however, we need to allow for both trade and conflict. One possibility is to analyze a model with complementarities in production or consumption like the one that was briefly specified in section 2. Findlay and Amin (2000) and Skaperdas and Syropoulos (2001) have analyzed such models. They find conditions under which free trade can be better than autarky as well as the other way around.

The key in making such comparisons is whether security costs (defense expenditures and other costs of conflict) under autarky can be lower than the same costs under trade. If they are and they are greater than the gains from the trade, then autarky can be better than trade. Security costs could be higher under trade if a disputed territory or resource (like oil or diamonds) has much higher value internationally than it would have domestically and thus induce higher security costs on the part of the adversaries. When, however, the disputed resource has less value internationally that it would have under autarky, security costs are lower under trade and free trade then is unambiguously superior to autarky.

Restraints and governance

As we have discussed extensively in section 2, anarchy does not imply warfare or economically-crippling cold wars and high levels of arming. Norms, international law, institutions, and organizations can limit the resources that are devoted to arming. An alternative to the anarchy of the international system is a more hierarchical, even imperial, form of governance. Without being able to get into any detail here, certainly that has been one major way that lower-levels of anarchy have evolved into states. In this context there has been a debate about the effects of hierarchical governance. Findlay (1990) and Grossman and Noh (1994) first examined setting in which the state is "proprietary;" that is, it is owned by someone who taxes and provides services so as to maximize profits. McGuire and Olson (1996) argued that such an arrangement can be nearly efficient but Moselle and Polak (2001) have found several problems with that argument. Furthermore, Konrad and Skaperdas (1999) have argued that monopolistic governance invites competition and competition between different proprietors would eliminate all efficiencies and lead to a higher level of organized anarchy (see also Greif et. al., 2000, for another comparative treatment of the emergence of governance through violence). That is, breaking down anarchy by creating a hierarchical order does not look theoretically promising in addition to the objections one might have on empirical grounds.

Future prospects

One main weakness of the approach reviewed in this chapter is the conception of states not only as unitary actors but also as not responding to concerns that are not material in nature. That might have been true up to about two centuries ago, when the state was indeed largely owned by King or Emperor and fighting to defend it was his private affair. Beginning with Napoleon, who

managed to motivate Frenchmen to fight for their own country, and the emergence of nationalism which is an integral element of the modern state, the world appears to have become more complex. Notions like "ideology," "legitimacy," or "sovereignty" do not have a place in the approach reviewed in this chapter, or at least they do not have one yet beyond those of norms for rules of division, but they do appear importance in practice. As far as I can tell, and as an outsider to the relevant debates I cannot be completely sure, these are also concerns directed against the realist school. It would be advisable to at least attempt thinking about how such notions could modify any insights that might come out of the approach reviewed here.

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