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War and conflict in economics: Theories, applications, and recent trends☆

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ABSTRACT

We review the main economic models of war and conflict. These models vary in details, but their implications are qualitatively consistent, highlighting key commonalities across a variety of conflict settings. Recent empirical literature, employing both laboratory and field data, in many cases confirms the basic implications of conflict theory. However, this literature also presents important challenges to the way economists traditionally model conflict. We finish our review by suggesting ways to address these challenges.

1. Introduction

While the study of economics is rooted in analysis of the possibilities for and impediments to mutual gain from exchange, in the mid-20th century the development of game theory initiated a flurry of study of more adversarial interactions. Soon

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Table 1
Research on war and conflict in economics.

	Description
(1) Definition of Conflict	A conflict is a situation in which agents choose inputs that are (i) costly both to themselves and relative to some socially efficient optimum (ii) in pursuit of private payoffs framed as wins and losses.
(2) Foundational publications in economics	Borel (1921), von Neumann and Morgenstern (1944), Haavelmo (1954), Schelling (1960), Boulding (1962), Tullock (1980), Lazear and Rosen (1981), Fudenberg et al. (1983), Nalebuff and Stiglitz (1983), Hirshleifer (1988), Hirshleifer (1989).
(3) Methods used to study conflict/war	To study conflict, economists commonly use: - Formal game theoretic modeling - Empirical models using various econometric techniques - Laboratory and field experiments with human subjects
(4) Main models of conflict/war	Models of war and conflict: - Contest models: rent-seeking, all-pay auction, rank-order, difference-form - War of attrition games: dynamic contest models - Colonel Blotto games: multi-dimensional contest models - Guns versus butter models - Spatial conflict models

Note: we cite the first instance of a model, whether or not its intended context was conflict as we define it.

after von Neumann's interest in the strategy of chess led him to initiate the development of game theory (which he famously expanded upon with Morgenstern in 1944), economists began to use game theoretic models of strategic interaction to study conflict (Leonard, 2010). In fact, some of the earliest applications of game-theoretic reasoning were to wartime efforts, as proto-game theorists developed models that helped the US military optimize its search for German U-boats (accounting for the fact that the U-boat captains were themselves optimizing their movements to avoid detection) with von Neumann's help, even prior to the publication of *The Theory of Games and Economic Behavior* (Leonard, 2010, p. 272).[1]

This anecdote hints at key features of the economic approach to the study of conflict: economists tend to work with formal models of behavior in which decision-makers have well-defined objective (utility) functions. These models seek to define mutually optimal behavior (equilibria) such that decision-makers who consciously weigh the marginal costs and benefits of their actions, accounting for the fact that their adversaries are doing the same, will be unable to unilaterally change their strategies to their benefit. As Schelling (1960) put it, "[t]he advantage of cultivating the area of 'strategy' for theoretical development is not that, of all possible approaches it is the one that evidently stays closest to the truth, but that *the assumption of rational behavior is a productive one*" (p. 4, *emphasis* added). When considering the decision to enter a conflict, or how to behave once a conflict has begun, economic models describe agents whose choices are shaped solely (or at least primarily) by incentives. Thus economic models of the outbreak of conflict tend to look for changes in the value of contestable resources (that increase the benefit of violently monopolizing those resources), or for changes in the capacity of some group to defend its existing resources (that reduce the cost of conflict for potential attackers). Similarly, models of the duration and intensity of conflict hinge on contestants' gains from (and likelihood of) victory.

In recent years, models of conflict have begun to incorporate alternative assumptions about the preferences or information-processing abilities of agents in an attempt to more nearly capture the actual decision-making processes of individuals facing conflict. In such models, agents are nevertheless typically assumed to choose an optimal action, given whatever additional constraints are imposed by the modeler. For example, modelers have assumed that some individuals gain additional utility from the simple fact of *winning*, independent of the prize won, as a potential account of high conflict expenditures (see Cox et al. (1988) for a theoretical treatment, Goeree et al. (2002) for an empirical strategy to identify the joy of winning, and Sheremeta (2010) for an experimental method directly measuring joy of winning). In a related direction, increasing attention has been paid to the behavioral *consequences* of conflict, as for example, in recent evidence that conflict can induce a preference for certainty and/or encourage cooperation (Callen et al., 2014; Bauer et al., 2016).

In this survey, we describe the key theories of war and conflict developed by economists, as well as recent trends in the study of conflict in prominent economics journals, and we conclude by suggesting directions for future research. Table 1 summarizes the economic approach to the theory of conflict. We begin by providing a definition of conflict that allows us to clearly delineate which sorts of interactions we have in mind. Following Garfinkel and Skaperdas (2007) we define conflict as a situation in which agents choose inputs that are costly, both to themselves and relative to some socially efficient optimum, in pursuit of private payoffs framed as wins and losses. Early models of conflict assumed these input costs were sunk, and looked at the strategic allocation of sunk resources (such as Colonel Blotto games); later models endogenized the input decision with explicit costs (as in all-pay auctions), or implicit opportunity costs (as in the foregone domestic production in guns-versus-butter models). Such a definition excludes cases where competition between agents is efficiency-enhancing,

[1] Related work continued at the RAND Corporation during the Cold War, as game theory gained a wider audience among mathematicians, statisticians, and economists at the intersection of government and industry.

particularly industrial organization (IO) models of price wars, Cournot, and Bertrand competition in which the competitive choices of firms reduce prices towards the (Pareto efficient) competitive equilibrium. We will however discuss IO studies where the nature of competition fits our definition of conflict above, such as R&D contests or wars-of-attrition. Principal-agent models are also excluded from this review because, although the agent's effort is individually costly, it is socially efficient. However, we do cite some seminal papers in the field of labor economics that developed models to analyze principal-agent relationships which were later applied to conflict generally (such as rank-order and difference-form contests).[2]

As the study of conflict in economics advanced, economists developed a number of distinct, but related, models of conflict and worked out their implications in detail. For example, Tullock (1980) introduced a workhorse model of conflict, known as a rent-seeking contest in which contestants exert costly efforts, and their probability of winning some prize is equal to the conflict investment generated by their own effort divided by the total conflict investment generated by all contestants' efforts. Game theoretic analysis of this model generates predictions about how the intensity of conflict depends on the prize value, the asymmetry between contestants, the number of contestants, and so on. In Section 2 we explore this and other models in more detail. We will see that economic models of conflict are diverse, but all agree on the key implication that conflict is costly. The costs of conflict come in three main forms: "(1) foregone opportunities, as when guns are produced instead of butter; (2) attrition of the resources actually devoted to combat, for example, military casualties; (3) collateral damage to productive resources" (Hirshleifer, 1991, p. 130). Given the costs of conflict, another common theme in conflict theory is seeking means of reducing these costs or avoiding conflict altogether.

In Section 3 we review the recent literature on conflict to ask where the field has been recently. We review recent papers testing the implications of the well-known models of conflict in diverse settings as well as a strand of empirical literature studying the effects of conflict on other economic quantities of interest (prices, preferences). We also review empirical evidence suggesting the need for revision of current theory, in particular in the direction of more accurately modeling the objectives of contestants to account for motivations beyond the value of the prize itself. In Section 4 we further speculate about the future of the field and suggest a few possible directions for novel work that will address important unanswered questions. Section 5 concludes.

2. Models of war and conflict

In this section, we describe the workhorse models used to study conflict in economics. We discuss the origins of these models, highlight some of their implications, and briefly discuss the relationship of the models with existing empirical evidence.

2.1. Contest models: rent-seeking contest, all-pay auction, difference-form contest, and rank-order tournament

Contest models are among the most common tools to used to describe conflict in economics. The two most popular contest models are the rent-seeking contest model of Tullock (1980) and the all-pay auction, which appeared in Nalebuff and Stiglitz (1983), and is described in detail in Hillman and Riley (1989). Both models assume that players exert costly irreversible resources while competing for a prize. To illustrate, assume that there are two players, $i = A, B$, competing for a prize value of v. Players choose inputs x_A and x_B and incur a cost $c_i(x_i)$ to do so. The probability of winning is frequently called the contest success function and is a function of the chosen inputs $p_i(x_A, x_B)$, resulting in an expected payoff to player A (similarly player B):

$$\pi_A(x_A, x_B) = p_A(x_A, x_B)v - c(x_A) \tag{1}$$

The contest success function can take many forms. Generally the probability of winning is weakly increasing in one's own costly inputs. For example, (Skaperdas, 1996) describes a contest success function of the form:

$$p_A(x_A, x_B) = \frac{(x_A)^r}{(x_A)^r + (x_B)^r} \text{ if } x_A + x_B > 0 \tag{2}$$

and $p_A(x_A, x_B) = 1/2$ if if $x_A = x_B = 0$. Here, r can be thought of as the conflict effectiveness parameter. In the rent-seeking contest, $r = 1$ in (2), the probability of winning equals the ratio of a player's expenditures to the sum of expenditures by both players. In the all-pay auction, $r = \infty$ in (2), the player with the highest expenditure wins the prize with certainty.

Some of the early literature on contests – in which contest success is based on *relative* rather than *absolute* costly input levels – was generated in the context of optimal labor contracts in a principal-agent setting. For example, Lazear and Rosen (1981) described the normative benefits of a rank-order contest, but their paper is now widely cited in studies of conflict. Similarly, Nalebuff and Stiglitz (1983) mostly focused on compensation schemes when they popularized the difference form contest, in which the probability that a player wins depends on the difference between the players' expenditures x_A and x_B. Hirshleifer (1989) is an early example that explicitly discussed the usefulness of such contest models to study conflict more generally, including military combat and election campaigns.

[2] Each of the models referenced in this paragraph will be outlined in more detail in Section 2.

The exact equilibrium predictions depend on the specific parameters and the type of model in use. For example, in the rent-seeking contest, where $r = 1$ and $c(x_A) = x_A$ in Eq. (2), the Nash equilibrium prediction is for each player to spend $x_A^* = x_B^* = v/4$ in the process of competition (Tullock, 1980), implying that each player should have an equal probability of winning in equilibrium, i.e., $p_A(x_A^*, x_B^*) = p_B(x_A^*, x_B^*) = 1/2$. In the all-pay auction, where $r = \infty$ and $c(x_A) = x_A$, the Nash equilibrium prediction is for each player to randomly choose a level of expenditure from a uniform distribution on the interval [0, v] (Hillman and Riley, 1989), again leading to an equal probability of winning in equilibrium. This simple formulation of the rent-seeking contest and the all-pay auction demonstrates the social inefficiency of conflict. Both players could achieve the same probability of winning with no expenditures, i.e., if $x_A = x_B = 0$ then $p_A(0, 0) = p_B(0, 0) = 1/2$. However, in equilibrium, own-payoff-maximizing economic agents engage in an unproductive conflict by spending costly resources. The structure of information is also a critical component of equilibrium. Amann and Leininger (1996) expanded our theoretical understanding of all pay auctions to incorporate incomplete information, and empirical tests of this environment by Noussair and Silver (2006) demonstrated expenditures above the equilibrium prediction, in line with a winner's curse or joy of winning interpretation.

Traditionally, these four contest models – rent-seeking, all pay auction, difference form, and rank order – have been applied to different areas of economic analysis. For example, the rent-seeking contest has been commonly used in the study of rent-seeking competitions, while the all-pay auction has been used in lobbying and military applications (see the review by Dechenaux et al., 2015). Over the years, extensions of these models have provided valuable theoretical predictions regarding strategic behavior in conflicts (see the review by Konrad, 2009). One of the most well-established theoretical results is the incentive effect: the aggregate level of conflict increases in the size of the prize. Another well-known result is the size effect: the aggregate level of expenditure increases as the number of contestants increase (although per capita expenditure may actually decrease). When the contest is between asymmetric players, the weakest player's optimal costly input is decreasing in the degree of asymmetry between players (Baye et al., 1993, 1996; Baik, 1994). The reason for this is the "discouragement effect": weaker players strategically cut back expenditures when facing a stronger player.

The main predictions of contest models have been tested in the field (Prendergast, 1999; Szymanski, 2003; Connelly et al., 2014). Generally, empirical studies find support for the main predictions of the theory, such as the incentive effect (Knoeber, 1989; Ehrenberg and Bognanno, 1990; Becker and Huselid, 1992; Knoeber and Thurman, 1994), the size effect (Boudreau et al., 2011; List et al., 2014), and the discouragement effect (Brown, 2011; Berger and Nieken, 2016).

Theoretical models of contests have also been extensively tested in controlled laboratory settings. Most laboratory studies also find support for the main predictions of the theory, such as the incentive effect (Bull et al., 1987; Van Dijk et al., 2001), the size effect (Gneezy and Smorodinsky, 2006; Sheremeta, 2011; Morgan et al., 2012) and the discouragement effect (Davis and Reilly, 1998; Fonseca, 2009). However, experimental studies also uncovered a number of important phenomena which are not predicted by the theory. One such phenomenon is over-expenditure of resources (also known as overbidding or overdissipation): the average expenditure of participants in laboratory experiments is significantly higher than predicted by the Nash equilibrium. This finding was first discovered by Millner and Pratt (1989), and since it has been replicated by numerous other experiments (see the review by Sheremeta, 2013). The magnitude of over-expenditure in some studies is so high that on average participants receive negative payoffs. The phenomenon of over-expenditure has attracted much attention, and a number of explanations have been offered. Some of the common explanations include non-monetary utility of winning, mistakes, systematic biases, relative payoff maximization, and impulsivity (see Sheremeta, 2015, for a summary).

2.2. War of attrition games: dynamic contest models

While contest models are a popular tool among economists to analyze incentives in war and conflict situations, most canonical models do not capture the fact that conflicts may last for a long period of time and a common strategy may be to wear down the enemy over time. Maynard Smith (1974) was among the first to formally describe what is now known as a "war of attrition". In the original formulation of the game, each of two players must choose a time at which to concede. The return to conceding decreases with time, but, at any time, a player earns a higher return if the other player concedes first. An alternative formulation of the game, called the "tug-of-war", is a contest consisting of a series of battles, where one player wins the war if the difference in the number of battle victories exceeds some threshold.

In general, the war of attrition can be modeled as a dynamic contest in which two players, A and B, engage in multiple battles for a single prize value of v. The expected payoff of player A (similarly player B) can be written as:

$$\pi_A(\{x_A^t\}_{t=1}^T, \{x_B^t\}_{t=1}^T) = p_A(\{x_A^t\}_{t=1}^T, \{x_B^t\}_{t=1}^T)v - c(\{x_A^t\}_{t=1}^T) \tag{3}$$

Here, the contest can last for T periods (battles), the probability of winning by A depends on expenditures of both players in all periods, i.e., $\{x_A^t\}_{t=1}^T$ and $\{x_B^t\}_{t=1}^T$, and the cost of expenditure depends on expenditures of player A in all periods, i.e., $\{x_A^t\}_{t=1}^T$.

The war of attrition game has been studied extensively in economics. One of the earliest theoretical papers by Fudenberg et al. (1983) shows that a player lagging behind by more than one battle drops out of the contest and, as a result of this discouragement effect, in equilibrium players compete to gain strategic momentum by exerting most of their resources at

the beginning of the contest (the "frontloading" effect).[3] Theoretical papers have also examined the impacts of the sequence of decisions (Wolfgang et al., 1994), asymmetry between players (Hammerstein and Parker, 1982; Budd et al., 1993), varying discount factors (Harris and Vickers, 1987; Fudenberg and Tirole, 1986), budget constraints (Leininger, 1991), intermediate rewards (Konrad and Kovenock, 2009; Gelder, 2014), and path-dependent conflict ability (Beviá and Corchón, 2010). Commonly, these studies find that conflict intensity increases in the prize value and the size of intermediate rewards, and that it decreases in the magnitude of strategic momentum (how far one player is ahead of the other).

With naturally-occurring data, it is difficult to study war of attrition-style games because of self-selection, unobservables, and unavoidable endogeneity in dynamic settings. Nevertheless, there are some exceptions. Klumpp and Polborn (2006), for example, provide evidence for strategic momentum and frontloading in the context of the U.S. presidential primaries. Support for strategic momentum is also found in sports settings (McFall et al., 2009; Malueg and Yates, 2010; Irfanoglu et al., 2015). Other recent papers discussed in Section 3 suggest that clever empirical techniques are being developed to take this model to the field. For example, Augenblick (2016) uses the data from a penny auction to show that competition in a war of attrition-style contest is more intense and longer-lasting than predicted (perhaps due to the sunk-cost fallacy).

Given the difficulties of testing the war of attrition with naturally-occurring data, researchers have also conducted a variety of laboratory experiments. The flexibility available in such experiments allowed researchers to test a variety of implications of these models, including the consequences of asymmetry between players, fatigue, the length of competition, intermediate rewards, and contest structure. Echoing the findings of empirical studies, experimental studies find significant support for strategic momentum (Mago et al., 2013; Irfanoglu et al., 2015). Also, consistent with the theory, conflicts escalate with the introduction of intermediate rewards (Mago et al., 2013; Gelder and Kovenock, 2017), and asymmetric contests tend to be resolved in favor of the contestant with the advantage (DeScioli and Wilson, 2011; Oprea et al., 2013). However, contrary to the theoretical prediction of frontloading, conflicts tend to last too long and remain intense in the latter stages (Zizzo, 2002; Hörisch and Kirchkamp, 2010; Deck and Sheremeta, 2012; Deck and Kimbrough, 2015), though Ryvkin (2011) finds some evidence of conflict fatigue. Finally, similar to the findings from all-pay auction and rent-seeking contest experiments, almost all studies mentioned above find that the average expenditure of participants in war of attrition experiments is significantly higher than predicted by the risk-neutral Nash equilibrium.

2.3. Colonel Blotto games: multi-dimensional contest models

Perhaps one of the earliest formal analyses of strategic behavior in wars goes back to the original formulation of the Colonel Blotto game by Borel (1921). In the original game, two players, A and B, simultaneously allocate their resources across $N = 3$ battlefields. If A allocates x_A^i and B allocates x_B^i units to the ith battlefield, the player who allocates the higher level of resources wins battlefield i (similar to the all-pay auction). The winner of each battlefield receives a prize v, so the objective of each player is to win as many battlefields as possible (this is also often referred to as the "additive objective"). In the original constant-sum game, both players have identical endowments of resources, $X_A = X_B$, and resources which are not allocated to one of the battlefields are forfeited and lose all value to the player. Therefore, the Colonel Blotto game can be thought of as a multi-dimensional contest in which individual contests are linked though a budget constraint. The expected payoff of player A (similarly player B) can be written as:

$$\pi_A(\{x_A^i\}_{i=1}^N, \{x_B^i\}_{i=1}^N) = \sum_{i=1}^{N} p_A^i(x_A^i, x_B^i)v \text{ s.t. } \sum_{i=1}^{N} x_A^i = X_A \tag{4}$$

An equilibrium of this game, first identified in Borel and Ville (1938), is for each player to use a "stochastic complete coverage" strategy, by allocating random, but positive, resource levels across all battlefields.

Over the years, the Colonel Blotto game has been extended theoretically to non-constant-sum games (Kvasov, 2007; Roberson and Kvasov, 2012), majoritarian objective (Szentes and Rosenthal, 2003), discrete budgets (Hart, 2008), asymmetric resource endowments (Roberson, 2006), asymmetric objectives (Clark and Konrad, 2007; Holt et al., 2016), asymmetric battlefields (Gross and Wagner, 1950; Young, 1978), incomplete information (Hortala-Vallve and Llorente-Saguer, 2010), and alternative contest success functions (Friedman, 1958; Snyder, 1989). These models are complex and difficult to analyze, but perhaps one of the most robust theoretical results pertains to the impact of asymmetry between players on their behavior (Kovenock and Roberson, 2012): stronger players use the stochastic "complete coverage strategy" (attacking all battlefields with random force), while weaker players use a "guerilla warfare strategy" (attacking only a sub-set of battlefields).

The most common way of testing the theoretical predictions of a Colonel Blotto game is by using laboratory experiments (see the review by Dechenaux et al., 2015). Surprisingly, the complex theoretical models perform fairly well in the laboratory. Avrahami and Kareev (2009), for example, conclude "the results indicate that naïve players can behave, intuitively, in a way

[3] In the theoretical literature on dynamic contests "frontloading" is usually referred to as a phenomenon where most of the resources are exerted in the first battle. This robust phenomenon has been documented in the case where individual battles are modeled either as all-pay auctions (Harris and Vickers, 1985; Konrad and Kovenock, 2005) or as lottery contests (Klumpp and Polborn, 2006); however, in the case of lottery contests, frontloading is less pronounced. Also, frontloading is less pronounced when there are intermediate prizes (Konrad and Kovenock, 2009) or when the final reward is more immediate (Konrad and Kovenock, 2005).

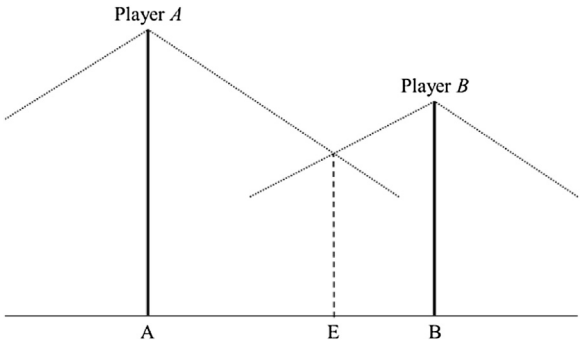

Fig. 1. Boulding's basic model of spatial conflict.

that approximates the sophisticated game-theoretic solution," while Chowdhury et al. (2013) write ". . .it took only one hour for subjects who were unfamiliar with this game to exhibit behavior consistent with equilibrium." At the same time, a number of experiments document interesting deviations from the theoretical predictions. For example, experimental studies show that instead of using a theoretical "stochastic complete coverage" strategy, players often use a "guerilla warfare strategy", and they overbid in non-constant sum Blotto games (e.g., Deck et al., 2016; Montero et al., 2016; Kovenock et al., 2016). This type of behavior can be explained by a multi-dimensional iterative reasoning (Arad and Rubinstein, 2012), whereby players choose to focus on certain dimensions of strategy, such as the number of battlefields or the allocation amount to each battlefield.

2.4. Guns versus butter models

In these models, which attempt to integrate the study of conflict into the broader study of economic activity, agents face a tradeoff between producing goods and taking what others have produced (or investing in self-defense). Haavelmo (1954) introduced the tradeoff between "guns" and "butter" in a classical framework, which was further advanced by Hirshleifer (1988), among others. To provide the intuition, assume that two players, A and B, possessing resource endowments, R_A and R_B, need to decide how to allocate their resources between production of butter, y_A and y_B, and guns, x_A and x_B. Butter is used to increase the size of economy of each player, while guns are used to increase the probability of capturing resources of both players, i.e., $y_A + y_B$. Therefore, the expected payoff of player A (similarly player B) can be written as:

$$\pi_A(x_A, y_A, x_B, y_B) = p_A(x_A, x_B)(y_A + y_B) \text{ s.t. } x_A + y_A = R_A \tag{5}$$

Note that the main difference from the standard contest model (2) is that the prize is endogenous, i.e., $y_A + y_B$, and the cost of producing guns is the opportunity cost of not producing butter, i.e., $x_A = R_A - y_A$. If we assume that the probability of winning the prize is given by $p_A(x_A, x_B) = \frac{x_A}{x_A + x_B}$, then the Nash equilibrium prediction is for each player to spend $x_A^* = x_B^* = (R_A + R_B)/4$ on producing guns and $y_A^* = R_A - x_A^*$ and $y_B^* = R_B - x_B^*$ on producing butter. This result is sometimes referred to as "the paradox of power": in equilibrium, the weaker player (with the lower amount of resources) is able to achieve the same expected payoff as the stronger player by investing relatively more resources in producing guns (Hirshleifer, 1991; Garfinkel and Skaperdas, 2007). Another somewhat counterintuitive theoretical result coming from this literature is that conflicts are more likely to occur in "the shadow of the future", i.e., as the future becomes more important (Powell, 1993; Skaperdas and Syropoulos, 1996; Garfinkel and Skaperdas, 2000; Robson and Skaperdas, 2008).

Laboratory experiments testing guns versus butter models find significant support for the comparative static predictions of the theory. For example, Durham et al. (1998) find substantial support for the "paradox of power" by showing that the weaker players tend to achieve payoffs similar to the stronger players; see also Powell and Wilson (2008). Tingley (2011) and McBride and Skaperdas (2014) find that conflicts escalate in "the shadow of the future" by showing that subjects are more likely to engage in destructive conflict as the future becomes more important, while Kimbrough et al. (2014) find in a laboratory setting that conflicts are more likely to occur when players are relatively asymmetric.

2.5. Spatial conflict models

In his classic work, Boulding (1962) models conflict over territory by adapting economic theory on spatial competition (e.g., Hotelling, 1929). Boulding was interested in the geographic conditions under which one party can conquer another. The basic model is shown in Fig. 1. Two players, A and B, have their centers of power (bases) located at points A and B. Measured vertically is the military strength of each player depending on how far they are from their base. It is reasonable to assume that each player's strength is at a maximum at the home base, from which it falls in either direction. Both players are equally strong at location E, and thus this location might be expected to be a source of conflict and/or to emerge as the border between the two players' territories.

This basic model can be extended to capture defensive and offensive differences (e.g., technologies that alter the slope of the decline, modeling the projection of power), multiple bases, buffer zones (see the review by Anderton and Carter, 2009), as well as multiple dimensions (O'Sullivan, 1991). The general idea that geographic constraints may shape the likelihood of conflict is intuitive: the likelihood of conflict will depend in part on the ability of two parties to reach one another with military force. For instance, the absence of conflict between European people and South American people until the last 500 years can readily be explained by the geographic barriers posed by the Atlantic ocean. Thus recent empirical work studying the sources of conflict has attempted to account for geographic barriers to the outbreak of conflict (Spolaore and Wacziarg, 2016).

2.6. Conflict avoidance

Throughout this survey we have stressed that conflict is by its nature inefficient, which is one reason why economists are well-suited to research the phenomenon: we have longstanding theories that clearly delineate between the outcome which is best for society and that which is achieved by agents acting solely in their own self-interest.

Coase (1960) was the first to note that in a number of legal cases in which one self-interested agent caused a nuisance externality to another, that the socially efficient outcome could be achieved by allocating property rights to either one of the parties and allowing them to bargain to find a mutually agreeable price and quantity of the nuisance. Cheung (1969) extended this concept with rigorous theory to demonstrate that in the absence of transaction costs, any institution could achieve an efficient allocation.

These ideas were later extended and applied to the formal study of conflict using the models introduced earlier in this section. For example, in the guns versus butter model described by Eq. (5), any positive value of guns (x_i) for either player is socially inefficient; both agents A and B could reduce their amount of guns proportionally such that $p_i(x_A, x_B)$ is unchanged and the pie ($y_A + y_B$) is increased, leaving both agents with greater expected payoffs. Similarly, the efficient outcome in an all-pay auction is to have every agent bid zero, and in a dynamic war-of-attrition, the efficient outcome is to have all but one agents exit the market at the first opportunity. Generally, the failure to accomplish such co-ordination is the result of an inability to communicate or bargain (Coase, 1960), transaction costs (Cheung, 1969), or in a dynamic setting, an inability to commit to an agreement once it is reached (Acemoglu, 2003), which may be especially salient in conflict between states.

A substantial theoretical literature demonstrates that by solving any one of these issues, conflict could be avoided. For instance, theoretical results suggest that conflicts can be avoided through communication (Crawford and Sobel, 1982; Kreps and Wilson, 1982; Milgrom and Roberts, 1982), contracting and side-payments (Hirshleifer, 1995; Muthoo, 2004; Beviá and Corchón, 2010), centralization Grossman (2002), extensive armament (Schelling, 1960; Garfinkel, 1990; Grossman and Kim, 1995; Smith et al., 2014), and also through political systems that emphasize open, rule-governed competition (North et al., 2009).

Many of the conflict avoidance mechanisms have been studied in the laboratory. Experimental studies show that, consistent with the theoretical predictions, conflicts can be avoided through communication (Tingley and Walter, 2011; Cason et al., 2012), side-payments (Kimbrough and Sheremeta, 2013, 2014), centralization Duffy and Kim (2005), and armament (Carter and Anderton, 2001; Smith et al., 2014). However, as predicted, inability to commit to a proposed resolution can exacerbate conflict (Kimbrough et al., 2015). Moreover, in the absence of binding enforcement, allowing the formation of endogenous groups for the purpose of mutual protection similarly fans the flames of conflict (Smith et al., 2012; Rogers et al., 2013).

3. Recent trends in the study of war and conflict

Here we conduct a systematic survey of papers published in five prominent economics journals (American Economic Review, Econometrica, Journal of Political Economy, Quarterly Journal of Economics, and Review of Economic Studies) in the last 5+ years (2011-2016) to identify patterns and trends in the literature on the economics of conflict.

To generate an initial list of papers, we searched from the website of each of the five journals above for all papers which contained the following words in the title, abstract or keywords: *(war, warfare, war-of-attrition, conflict, violence, contest, all-pay, faction, coup, revolution)*. Where they are available, we also included all papers with the following JEL identifiers: *(D74, F51, F52, F54, H56, N4)*.[4] We excluded invited papers and lecture transcripts. This initial list contained 85 papers. We then excluded 13 papers in which a war or conflict was used as a timeframe or control variable to study an unrelated topic.[5] An additional 23 papers were excluded in which the interaction of interest did not meet our definition of conflict, most frequently this was because a keyword was used with a different meaning in a study of unrelated economic phenomenon.[6]

[4] D74: (Conflict, Conflict Resolution, Alliances, Revolutions); F51: (International Conflicts, Negotiations, Sanctions); F52: (National Security, Economic Nationalism); F54: (Colonialism, Imperialism, Postcolonialism); H56: (National Security, War); N4: (Government, War, Law, International Relations, and Regulation); source: https://www.aeaweb.org/econlit/jelCodes.php.

[5] For example, Jha (2015) studies political attitudes during the English revolutionary war of 1642-1648.

[6] For example, Goeree and Yariv (2011) study how communication protocol affects social choice outcomes when agents have either common or *conflicting* interests, with reference to juries.

Appendix Figures A2–A6 catalog the initial list of papers in each of the five journals of interest with a detailed justification for each paper we excluded from this review.

In this section, we organize our comments on the 49 papers meeting our search criteria by the model of conflict featured most prominently. The purpose of this is to introduce the reader to the cutting edge of research with respect to each class of models we outlined in Section 2. We believe this serves a pedagogical purpose by making it easier for the reader to refer back and understand how the complex versions of models being used today relate to their canonical bases.

3.1. Contest models

Recent research involving contests has expanded our understanding of the established results mentioned in Section 2.1 and further developed the theory to address novel contexts. The recent literature provides confirmation of some of the predictions of contest theory, e.g., in empirical work showing that changes in incentives to initiate and participate in conflict do, in fact, change the likelihood of conflict in a manner predicted by conflict theory (see e.g., Dube and Vargas, 2013; Powell, 2013; Fearon, 2011), and that the size and discouragement effects are visible in the context of government lobbying (Kang, 2016). We also see extensions of conflict models that enrich the conflict environment to consider variations in the timing of decisions, the information available to contestants, and the heterogeneity of contestants (e.g., Fu et al., 2015; Olszewski and Siegel, 2016). Similarly, analyses of conflict have been expanded to consider interactions between different kinds of contestants, for instance conflicts between state and non-state actors (De Mesquita, 2013; Powell, 2013; Fearon, 2011; Esteban et al., 2015) or between ethnic groups (Esteban and Ray, 2011; Esteban et al., 2012; Mitra and Ray, 2014), and a number of papers consider the influence of third-parties on conflict frequency and outcomes (Baliga and Sjöström, 2012; Hörner et al., 2015; Dekel and Wolinsky, 2012). We describe these papers in somewhat more detail below.

In a contest between a state and an insurgent group over regional resources, Dube and Vargas (2013) establish that the nature of the resource's production technology matters for the incentive effect; by studying the effect of commodity price shocks on violence in regions of Colombia, they show that positive price shocks in capital-intensive natural resources like oil and gold cause the expected increase in conflict from the incentive effect, but that positive shocks to labor-intensive resources like coffee actually reduce conflict. The authors propose a labor market driven mechanism in which civilians who might otherwise have become involved with the insurgency have an improved outside option in coffee production.

Fu et al. (2015) use the setting of a team contest consisting of multiple pairwise battles between agents with heterogeneous costs to study the intertemporal nature of the discouragement effect – a choice to quit in response to an early and perhaps lucky lead by an opponent.

By studying seven specifications of information and timing in all-pay and Tullock contests, they derive a number of "neutrality" conditions that eliminate the discouragement effect, in particular it vanishes when players are not repeatedly matched against the same individual. Olszewski and Siegel (2016) study large contests between players, whose degree of heterogeneity is generalized to being drawn from different distributions. Such a context creates difficulty in computing equilibrium outcomes, but they theoretically establish that these outcomes can be approximated instead by modeling a single individual with a continuum of possible types who matches assortatively to prizes.

Contest models modified to explicitly focus on conflict between a government and civilians have also recently received substantial attention. Briefly, their findings indicate that state counterinsurgency efforts can cause increases in guerilla violence (De Mesquita, 2013), that governments will undergo sectarian mass killings in order to consolidate power after a war (Esteban et al., 2015), and that such government violence is more likely when it has coercive power over rebel forces in the form of an ability to reduce the rebel payoff to fighting (Powell, 2013). In considering the other side of this relationship, Fearon (2011) shows that the threat of civilian violence against the government can generate a self-enforcing democracy whereby it is in the best interest of the ruler to provide fair elections and public goods.

There are also recent developments in theoretical contests focusing on the relevance of third parties to bilateral contests. For example, Baliga and Sjöström (2012) demonstrates in a two-state "arms race" contest that a cheap-talk extremist can increase the likelihood of conflict between two states if their actions are strategic complements. Conversely the potential peace-inducing nature of third parties is seen in Hörner et al. (2015), who demonstrate that non-binding mediation can achieve the same bilateral allocation as a binding arbitrator if the mediator has an opportunity to collect private information from both sides. Kang (2016) models lobbying using an all-pay auction of heterogeneous players and demonstrates that despite a small effect on outcome probabilities, the return to Energy lobbying in the US is over 130 percent. The model provides further evidence of the size effect (more parties increases aggregate lobbying) and the discouragement effect (a most influential lobbyist will crowd out others). Dekel and Wolinsky (2012) study a contest between an incumbent and rival over corporate control in which it is possible to win control not only through share ownership but also by buying votes from board members, and find that this opportunity generally reduces overall efficiency (by increasing conflict costs).

Recently, economists have modified group contest models to better understand the role of ethnic differences in generating conflict. Esteban and Ray (2011) generate a contest model of group conflict and demonstrate that the equilibrium level of conflict is theoretically proportional to a linear function of domestic inequality, fractionalization, and polarization. Esteban et al. (2012) confirm the expected effects empirically, leading to a more nuanced understanding of conflict as a mixture of "greed" over private prizes and "grievance" over the allocation of public goods among groups. Mitra and Ray (2014) study Hindu-Muslim conflict in India and find evidence that conflict is increasing in Muslim wealth, though they do not claim to know which side is instigating in response.

3.2. Dynamic models of conflict

Much recent work employing dynamic contest models attempts to account for the empirical observation that there are many *persistent* intergroup conflicts (e.g., Baliga et al., 2011; Rohner et al., 2013; Acemoglu and Wolitzky, 2014; Gul and Pesendorfer, 2012), and this growing theoretical literature has been complemented by observational studies testing competing explanations of conflict persistence (e.g., Augenblick, 2016; Takahashi, 2015). A second strand of literature examining the influence of "obstinate" types and bargaining posture in dynamic models has improved our understanding about how concerns over reputation and the beliefs of opponents or third parties can be a driver of conflict (e.g., Atakan and Ekmekci, 2014; Embrey et al., 2015).

Dynamic contests are frequently used to model intergroup conflict. Rohner et al. (2013) emphasize the relationship between trade and inter-ethnic conflict in a search and matching model. They demonstrate conditions for persistent civil conflicts in a situation where previous conflicts erode trust between groups, diminishing the propensity to trade and increasing the incentive for conflict. While ethnicity is a key contextual factor, this study focuses on the persistence of conflict or the formation of "conflict spirals", and it is shown that coercive peace policies such as external peacekeeping cannot diminish such spirals in the long term. In a more general but analogous setting of competing teams, Acemoglu and Wolitzky (2014) generate spirals of conflict over time with overlapping generations in a dynamic matching model. However, they demonstrate that Bayesian individuals will eventually end the conflict by experimenting with peace. Similarly, Baliga et al. (2011) use a dynamic contest to study inter-state conflict in a situation where a nation's leader first chooses aggression or peace, and then is potentially held accountable to the preferences of the people (if his nation is a democracy). They derive a common result in war of attrition models known as "Schelling's dilemma" where aggressive strategies are strategic complements, and fear about another player's type leads to an inefficient conflict spiral. Gul and Pesendorfer (2012) modify the War of Attrition to a "War of Information" in which two political parties engage in a costly action and choose an optimal stopping time in their goal of influencing the information or beliefs of a decision maker. They show that one party becomes more aggressive if its cost decreases or its opponent's cost increases, and that the decision maker is better off when the two parties are closely matched.

Dynamic contests are often applied in non-violent contexts, but in the abstract such studies can provide hints at the dynamics in play for those who puzzle over observed inefficient conflicts even in the presence of a seemingly obvious win-win allocation. Atakan and Ekmekci (2014) use a war of attrition model in a search and matching wage-bargaining context in which some proportion of agents are obstinate types to isolate the impact of uncertainty about bargaining postures on the prevalence of bargaining delays and negotiation break downs. They demonstrate that in equilibrium the two sides either come to immediate agreement or else must engage in costly delays in order to build a reputation as an obstinate type to maximize expected lifetime payoffs. In an experimental implementation of this model, Embrey et al. (2015) demonstrate that subjects do, in fact, recognize the role of reputation and mimic obstinate types.

Recent empirical analyses of dynamic contests have illuminated additional factors that can create conflict persistence. Takahashi (2015) models a war of attrition using the US movie theatre industry in the 1950s, and demonstrates that the strategic interactions driving classical findings - in this case the desire to incur the fixed cost of remaining open in the hope opponents exit the market - could account for less than 5 percent of the observed exit delay, while omitted contextual factors like the degree of competitive intensity were much more important. As briefly discussed in Section 2.2, the empirical analysis of online penny auctions by Augenblick (2016) demonstrates the robustness of the finding that individuals are subject to a sunk-cost fallacy in the war of attrition. Using individual and aggregate bid data he constructs empirical hazard rates and demonstrates that "risk seeking preferences" and "joy of winning" are less likely explanations for such behavior than a "sunk cost model".

3.3. Blotto games

Multi-dimensional contests were originally formulated to study war, but recently economists have applied these models to politics and the attack and defense of computer networks. Persico et al. (2011) modify a multi-dimensional contest between political parties, in which decision making is decentralized to a party faction in each region. Within each region, an all-pay auction occurs when each party faction chooses a costly effort level to procure a public good for the region, and the effort decision is based on both the region's propensity to swing based on winning a public good and strength of the party base. Notably, the location of resources in a factional equilibrium is different from that obtained in other models of distributive politics or other Blotto models. In particular, the factional model generates non-random biases of effort in favor of party strongholds, a bias that has been reported in many empirical studies of cross-sectional resource allocations. Of the papers included in our survey, perhaps the greatest deviation from typical application of economic models of conflict is seen in Goyal and Vigier (2014), who modifies a Blotto game to a situation in which a designer designs and defends a network against an attacker. The designer's overall payoff is convex in the number of network nodes, and she decides how to allocate defenses to those nodes; the attacker subsequently allocates resources across nodes to attack. In this general framework, it is shown that a non-random hub-and-spoke network with defenses concentrated at the hub is optimal for the designer in a variety of contexts. Both papers demonstrate how changes in the structure of a multi-dimensional contest can change the optimal strategies.

3.4. Guns versus butter models

Recent work using Guns versus Butter models have focused on bargaining, trade, and other means of avoiding conflict in political contexts and in the process highlighted why potential bargaining solutions break down or fail to reach fruition in the first place.

Acemoglu et al. (2012) expand our understanding of the discouragement effect by identifying situations in which war between asymmetric parties can be avoided entirely. They modify Hotelling and guns versus butter models to a conflict setting between one state with natural resources and one state with a military, and show that under some circumstances, regulation of prices and quantities by the resource-rich government can prevent the realization of war through the introduction of intertemporal distortions. However they also show that under some circumstances, regulation of prices and quantities can precipitate war in circumstances in which war is avoided in the competitive environment. This final result is viewed as evidence of the classical finding that conflict is frequently unavoidable, i.e., the best response, in an environment of limited commitment.

The guns versus butter concept of strategic resource allocation to prevent conflict has been extended to model intrastate conflict in a number of recent papers - this is one area of economics research that very closely overlaps with political science and endogenous theories of democracy. Such models involve a situation where an incumbent leader can allocate resources in an early stage (e.g., between private consumption, military, and other public goods), and agents respond with either violence or support. These players can be thought of as insurgents in the case of civil war, but also as elites or the electorate in models of political conflict where the leader hopes to avoid a coup or revolution. Besley and Persson (2011), Berman et al. (2011), Chaney (2013), Bai and Jia (2016), Francois et al. (2015), and Gennaioli and Voth (2015) all reflect this broad theme of "bargaining" between state and non-state actors and identify conditions under which changes in resource allocation will influence the likelihood of conflict.

3.5. Spatial conflict models

While we do not see many papers working with spatial models of conflict in the recent literature, empirical work has begun incorporating spatial variation in the value of contestable resources and the location of events to better understand the drivers of conflict. For example, Caselli et al. (2015) uses geo-referenced data on natural resource location and border location between pairs of states to establish that the incentive effect is increasing in the ease with which resources can be practically extracted and protected; for example onshore oil near a border is a greater driver of conflict than equivalent offshore oil deposits. This is analogous to the incentive effect; only rather than the gross prize size, conflict is increasing in the net prize size after accounting for the costs of defending and extracting the resource.

Geo-referenced data is also used in Aidt and Franck (2015), who examine the link between violent riots and political outcomes during Britain's Great Reform of 1832. Using the pre-reform voting record, the authors show that violence within 10km of an electoral region influences threat perception: first-hand experience of local violence was associated with a higher probability of electing a pro-reform (Whig) candidate. This finding will be important for those studying conflict over large areas, the effect of violence on beliefs is shown to be sensitive to spatial considerations.

3.6. Empirical analyses of the causes and consequences of conflict

A substantial literature on conflict has developed that exploits natural experiments, in which events are viewed as randomly assigned treatments possibly causing variation in conflicts or economic variables. There also continues to be a healthy literature focused on "Correlates of War", both conceptually and using the eponymous dataset.[7]

3.6.1. Causes of conflict

Three recent studies have exploited natural experiments to identify plausibly exogenous variation in variables thought to induce conflict. Dell (2015) examines violence between the Mexican government and drug cartels and finds that crackdowns by the right-wing PAN party account for at least half of the recent increases in Mexican homicides, offering a potential rebuke of hardline political approaches to domestic conflict. Yanagizawa-Drott (2014) show that propaganda can incite Rwandan civilians to violence and can even have spillover effects on those not reached directly. And while they do not explicitly model agent incentives, Card and Dahl (2011) demonstrate empirically that there is an increase in reports of domestic violence immediately following an unexpected loss by home football teams.

Two additional studies of the outbreak of conflict provide further support for the incentive effect. Both Crost et al. (2014) and Nunn and Qian (2014) provide evidence that initiation of a foreign aid program can increase civil violence in a region even when controlling for the endogenous nature of need and conflict and crowding out explanations; one potential mechanism suggested is the desire of insurgents to limit the effectiveness of the aid to maintain support among the population.

[7] The Correlates of War Project "seeks to facilitate the collection, dissemination, and use of accurate and reliable quantitative data in international relations" and provides data used in a substantial number of the empirical papers reviewed here. http://www.correlatesofwar.org/.

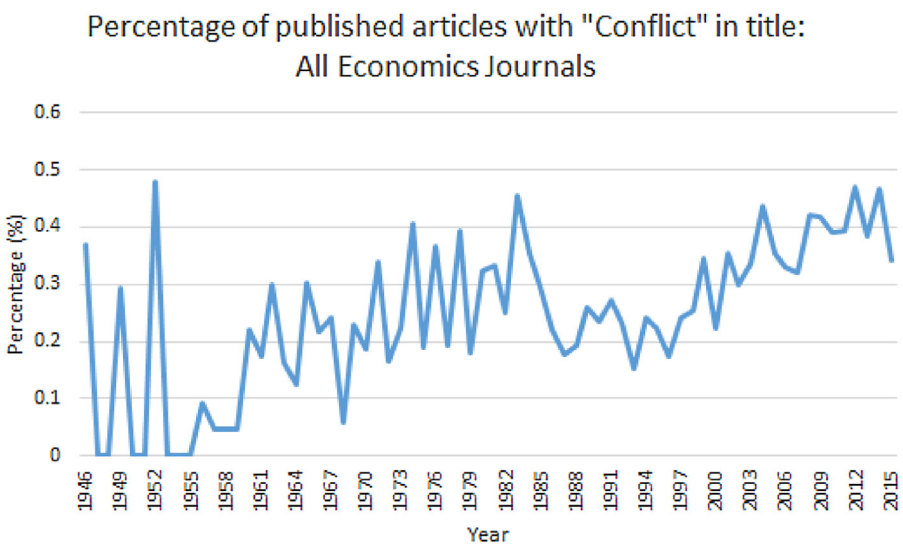

Fig. 2. Conflict-Related Papers in top Economics Journals, 1990–2015. The figure was generated based on five journals (*American Economic Review*, *Journal of Political Economy*, *Quarterly Journal of Economics*, *Econometrica*, *Review of Economic Studies*) and the search terms (*war*, *conflict*, *contest*, *all-pay*) commonly associated with theories of conflict in economics. Web of Science searches for articles within the given journals with these terms in the title were performed on 29 September 2016. Raw data and additional charts extending the time trend and normalizing for the total number of economics papers are available in the online appendix.

If we think of violent crime as a socially costly input decision in pursuit of a prize, economic analyses can help us understand the incentives to commit such crimes. Aizer and Doyle (2015) study the extent to which being incarcerated as a juvenile in Illinois causes an individual to commit violent crimes as an adult, using random judge assignment with different propensities to incarcerate as an instrumental variable. They find that among juveniles who faced any court case, those who were incarcerated were 6.1 percentage points more likely to be incarcerated for violent crime as an adult. Similarly to the coffee farmers in Dube and Vargas (2013), the proposed mechanism is a change in the value of an individual's outside option, in that being incarcerated as a juvenile is particularly disruptive to human capital formation, making violence less costly to the individual perpetrating it.

3.6.2. Consequences of conflict

Natural experiments have also been widely used to understand the effects of conflict on a range of variables of interest. The lessons from these natural experiments include: Civil War-related news influenced prices of US slaves similarly whether they were old or young, reflecting southern beliefs that Confederate secession from the Union would be successful (Calomiris and Pritchett, 2016); ethnic conflict led to decreases in productivity of inter-ethnic teams in Kenya (Hjort, 2014); population shocks caused by war (and disease) led to greater wage increases in medieval Europe than in China (Voigtländer and Voth, 2013); and that incidences of violent anti-Semitism in both pre-war Germany and WWII USSR had long-lasting negative regional economic effects (Acemoglu et al., 2011; Voigtländer and Voth, 2012).

Two recent experiments combine laboratory methods of measuring preferences with natural experimental variation in conflict to identify the effects of conflict on preferences. Voors et al. (2012) perform within-subject analysis of changes in preferences as a result of exposure to conflict; they do so by experimentally measuring the preferences for altruism, risk, and impatience among the same individuals in Burundi both before and after local exposure to violence (1999 and 2011). Individual altruism, risk-seeking, and impatience all increase in a community's exposure to violence, an important consideration to post-conflict governments seeking to encourage investment and provide public goods. In a similar analysis, Callen et al. (2014) demonstrates increasing preferences for certainty among Afghani individuals exposed to violence.

Other recent empirical papers suggest the existence of economic benefits of foreign conflict. Dube et al. (2011) studies the effect of CIA coups and coup authorizations on the stock price of multi-national companies operating in the country of interest, and finds potential evidence of insider trading through an increase in stock price following a CIA authorization of a US-friendly coup but before the coup itself. In a similar study, Berger et al. (2013) examine how CIA operations within a country affected bilateral trade with the US and find increases in direct foreign government purchases of US goods, potentially suggesting an economic benefit to the US from foreign conflict.

4. Future directions

The study of conflict is well-developed in economics with a long tradition in both theory and empirics. Even so, the last 25 years has seen increasing interest in the study of conflict among economists. Fig. 2 displays conflict-related papers that

were published in top economics journals between 1990 and 2015.[8] In this section we describe what we view as important directions for future research. We appreciate that it is difficult to speculate about which research agendas may be most fruitful, but we think such speculation is valuable, particularly as one of the goals of this special edition of JEBO is to inspire cross-pollination of ideas for conflict research across the social sciences.

4.1. Trends in the incidence of conflict

Despite the growing interest in studying war and conflict, some evidence suggests that the actual incidence of these phenomena is at a historical low (see Pinker, 2011). Probably the most important current research question in the study of conflict is to identify whether the trend of decreasing conflict is ongoing and, if so, why it has occurred and whether we can expect it to persist. Existing conflict models leave us with ambiguity, and we need to think carefully about how empirical observations map to theoretical quantities of interest. For instance, should we think of rising incomes and wealth around the world as increasing the value of contestable resources (which should encourage conflict) or as raising the opportunity cost of conflict for potential contestants? How should we think about the role of recent increases in income and wealth inequality in some countries in terms of the implied tradeoffs between productive and unproductive (conflictual) investment opportunities? As we have seen, some models predict that conflict will become relatively more attractive for poorer groups.

Hirshleifer (1995) argues that the answer to such questions is probably best answered in models that conceive conflict as a continuum, like the guns versus butter models, where the choice of an agent might be thought of as reflecting a steady-state level of conflict and the model's predictions can be understood to make statements about behavior in the long run. One productive avenue, then, would be to augment these models by introducing gains from exchange, potential for growth, and other economic possibilities that reflect the richness and complexity of alternatives to conflict in the real world.

4.2. Triggers of conflict

One downside of most economic models of conflict is that given the interpretation of their equilibria as steady-state outcomes, they have little to say about the triggers of actual instances of conflict. This leaves little room for such models to make specific policy recommendations designed to avoid particular instances of conflict. Unfortunately, this "weakness" may be inevitable if it turns out that the triggers of conflict are unique, context-specific events (e.g., the assassination of Archduke Franz Ferdinand, the "Soccer War"). On the other hand, some success of spatial models in predicting the likelihood of conflict due to the geographic distribution of contestable resources suggests that we may be able to make progress on this front.

4.3. Behavior in conflicts

While the theoretical literature on behavior in a variety of conflict "institutions" has grown, the empirical literature evaluating these theories remains somewhat less developed. One exception is the large literature on laboratory studies of conflict, and the findings from these suggest that some of the basic assumptions of economic models of conflict need to be re-evaluated. We know that the behavior of laboratory subjects frequently deviates from the optimal behavior of agents in theoretical models. The question remains whether the same criticisms can be leveled at these theories (or at the agents, depending on your perspective) when they are applied to real-world conflict actors.

Do states (paramilitary groups, etc.) behave optimally in the sense of our models or are they influenced by factors that are not typically considered in the theory? Are conflict agents outside the lab driven by emotion or by motivations other than the value of the contested prize (e.g., joy of winning or the sunk cost fallacy)? Does context matter in ways that theory based only on the payoff assigned to outcomes cannot predict (e.g., do agents in the field refuse settlements that are "too unequal" even though the resulting allocation dominates the expected value of conflict)? It seems uncontroversial to suggest that the answer to all of these questions is "yes", because conflicts are uniquely powerful experiences, often threatening the lives of contestants and offering ample opportunity for "non-standard" motivations to shape behavior. Nevertheless, these and other questions remain largely unanswered. Future theoretical work might seek to consider the implications of alternative objective functions based on experimental findings that individuals care about "fairness", "self-image", "social image", and "social identity", while also considering how to appropriately model such conflict-relevant emotions as "fear", "resentment", "hatred", "anger", and so on.

4.4. Modeling conflict actors

Typically conflict actors such as states are modeled as unitary actors with well-defined sets of preferences (usually monotonic over resources), but without explicitly modeling the generation of these preferences (e.g., as the outcome of democratic voting, as a balance of power among competing government actors, as the induced preferences resulting from

[8] Figure A1 in the online appendix shows that the percentage of economics papers with "conflict" in the title has been increasing since the 1950s.

a principal-agent problem between sovereign and bureaucrat, etc.). Occasionally models of conflict include the population of citizens or a median citizen (as a potential source of election or violent revolution, or as a source of information). In choosing a strategy, the state's preferences are generally fixed; the formation and change in these preferences as a result of the citizens' actions over time is not explicitly modeled.

Future models of political conflict that endogenize the dynamics between the preferences of a government and the optimal decision making of its heterogeneous citizens would improve upon the external validity of the literature as it applies to democracies, as it is reasonable to expect any democratic leader to consider the electoral consequences of either interstate or civil violence. Another possible implication of democracy for conflict behavior is that it may result in time-inconsistency or other "biases" since the preferences of voters may change in response to new information, chance events, or the outcomes of ongoing conflict. Similar arguments apply to other forms of government or to other processes by which governments change, with the broader implication that attempting to model in detail the institutional structures within which conflict actors are typically constrained to act might yield useful results, particularly with respect the influence of institutional "checks and balances" on the likelihood of conflict.

4.5. Conflict resolution

Given the clear implication that conflict is costly and wasteful, the goal of understanding conflict resolution is paramount. While many models suggest that mutually beneficial agreements to avoid a looming conflict are typically possible, the assumptions of such theories, e.g., that contracts are complete and enforceable and that agents are motivated solely by payoffs, may not be satisfied in practice. Thus there is a role for models that propose conflict-resolution mechanisms that work within the actual institutional environment faced by agents in the real world and for models that acknowledge that conflict resolution possibilities may differ when motivations and reasoning processes differ from those typically considered in economic models (e.g., when agents' emotions alter either their valuations or their abilities to assess their interests).

4.6. Novel conflict settings

One setting for conflict that has generally been overlooked by economists (at least within our search criteria) is cyber-conflict. In the abstract models of cyber-conflict might involve actions that are costly but generally not observable,[9] and prizes that are not material but take the form of information or a shift in beliefs. Theoretical and empirical analysis of such a setting could provide meaningful insight, and there is likely appetite for such analysis from policy makers. More generally, new technologies provide novel settings in which conflicts can occur and may suggest the need for new models of the kinds of constraints and opportunities for conflict (and conflict behavior) that these present. Similarly, economists may have something to contribute to the study of asymmetric violence between state and non-state actors (e.g., terrorism), though traditionally this is the purview of political science (e.g., Pape, 2003; De Mesquita, 2005; Fearon et al., 2007).

5. Conclusion

In sum, the theory of conflict in economics has a rich history and a bright future. From Borel (1921) and von Neumann and Morgenstern (1944) to the broad literature surveyed above, economists have created and adapted the latest theoretical and empirical methods to improve our understanding of situations "in which agents choose inputs that are (i) costly both to themselves and relative to some socially efficient optimum (ii) in pursuit of private payoffs framed as wins and losses." (see Table 1). Theoretical treatments of conflict range from quite general models examining the tradeoffs between conflict and production to more specific models examining optimal behavior in a variety of conflict "institutions". These models vary in many details, but their implications are in many ways qualitatively consistent, highlighting key commonalities across a variety of conflict settings. In recent years an empirical literature, employing both lab and field data, has developed, in many cases confirming the basic implications of conflict theory (e.g., that contestants fight harder for more valuable prizes, that asymmetry between contestants reduces weaker contestants' conflict expenditure, that valuable resources in more readily contested geographic areas are more likely to induce conflict, and so on). However, recent empirical evidence also presents important challenges to the way economists traditionally model conflict (and conflict actors). This body of research has grown rapidly and will continue to do so, in part addressing the challenges we have described above, and also by opening up new frontiers that we cannot foresee.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jebo.2017.07.026.

[9] However, see https://cybermap.kaspersky.com/.

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