

Article

On Some Connections between Negotiating While Fighting and Bargaining between a Buyer and Seller

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Abstract: We point out an equivalence between a class of games in which players negotiate while fighting and a class of games in which a buyer and seller negotiate over terms. Importantly and perhaps ironically, bargaining before fighting is strategically distinct from bargaining before a change of ownership but bargaining while fighting is equivalent to bargaining before a change of ownership. These connections and intuition from models of bilateral trade help shed light on two mechanisms for learning while fighting: inference based on observing strategic choices and information leakage on the battlefield. Debates on the relative importance of these two mechanisms are addressed; some subtle clarifications to extant arguments are provided. Moreover, the importance of learning hard information from the battlefield is connected to work on Coasian Dynamics with information leakage and avenues for future work relying on advances in behavioral theory are sketched out.

Keywords: bargaining; conflict; information; Coase



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1. Introduction

Central to scholarship on both inter and intra state conflict is the idea that conflict may result from strategic choices in the presence of asymmetric information about the costs of fighting, military strength or the value players assign to the disputed issue. Since Fearon (1995) [1] a host of game-theoretic papers have developed bargaining models with asymmetric information to study various facets of negotiations and conflict. Although asymmetric information is not the only mechanism driving war in game-theoretic models of conflict it remains one of the most relied upon mechanisms by scholars in this research tradition.

Among some scholars in this literature there is a folk-wisdom that the conflict bargaining models are similar to models of bargaining between a buyer and seller (for example Fudenberg, Levine and Tirole (1985)) [2] in which the disagreement point is a failure to trade. On the other hand some have emphasized stark distinctions. Wagner (2000, p. 478) [3] develops the contrast:

In the standard bargaining models used in economics, private information explains why agreement is not immediate, but the only way the bargainers have to reveal their private information is by temporarily refusing to agree. Since they determine whether and how long they will hold out, they have an incentive to use this decision to misrepresent their private information. As a result, the signals they give by deciding whether to hold out or not are noisy and can be interpreted only by taking into account the strategic incentives of the bargainers. These factors account for the great complexity of these models and the multiplicity of equilibria to them.

Bargaining in the context of war is different, in that fighting is a source of information that is much less subject to manipulation by adversaries.

Following Wagner, students of International Relations built dynamic models of negotiating while fighting which typically include exogenous pathways for information revelation

while fighting, so called learning from the battlefield, to capture the potential for this type of learning (Powell 2004, Slantchev 2003, Filson and Werner 2022) [4–6]. But often missing from this work is an appreciation that learning would happen even without the possibility of directly observing information on the battlefield¹. Absent, then, from the body of work on conflict bargaining is a clear understanding of the indirect or strategic learning channel that occurs when war is an inside option but does not occur when negotiations happen before fighting occurs. This paper seeks to reconcile these points and provide a constructive connection between models of negotiating while fighting and bargaining between a buyer and seller. The point can be summarized by returning to the quote by Wagner. Temporarily refusing to agree in the economics context is strategically equivalent to refusing to cease fighting in the war context. This is true because the cost of delay depends on one's payoff from fighting in the second case and the opportunity cost of not trading in the first case. So actions may reveal these payoffs prior to reaching a settlement. But, refusing to give up on negotiations (as in Fearon or potential models of negotiations before fighting) is distinct because it is impossible for one's payoffs from fighting to directly impact utility if a settlement is reached before fighting occurs. So negotiations before a purchase and negotiations before a conflict are distinct, but negotiations before a purchase and negotiations while fighting are equivalent (in a strategic sense).

Our perspective is complimentary with the models developed in Powell (2004), Slantchev (2003) and Filson and Werner (2002) [4–6] where strategic learning from delay also occurs. Powell takes a more optimistic perspective than Wagner arguing that there are similarities between the potential for screening in buyer-seller games and the screening in models of negotiating while fighting. Filson and Werner (2022) [4] illustrate how strategic offers induce screening. Slantchev (2003) [6] finds that learning from strategic choices (screening) can dominate the learning from hard information on the battlefield. We show that these observations are part of a more general connection². Not only are there similarities but a useful form of strategic equivalence holds between models in which fighting occurs until an agreement is reached (what Powell terms an inside option) and models of haggling between a buyer and seller in which trade occurs only after an agreement is reached. Interestingly, the seemingly more similar timing of not fighting while negotiating is strategically distinct. Our main contribution is to flesh this connection out and provide a concrete equivalence result³. In order to show the value of this equivalence we connect with extant work in the buyer seller context to show how the frequency of negotiations impacts the risk of war and nature of settlements. We also show that Powell's results that draw distinctions between whether the bargaining while fighting problem is one of private or common values really depend on what players learn before agreement is reached and are thus closely related to whether there is information leakage during delay in the buyer seller context.

Our key conceptual point is this: Early bargaining models like Fearon (1985) [1] that treated war as an outside option did not produce the kind of learning that comes from early models of haggling between a buyer and seller before a transaction because the kind of single crossing that occurs in buyer-seller models requires that countries fight until a negotiated settlement is reached. More recent dynamic models of bargaining while fighting with explicit channels for exogenous learning are probably more realistic but they often confound the channel of learning that comes from strategic choice and the channel of learning that comes from mechanical leakage. Moreover, this distinction can be made opaque when one looks at both problems of common and private values.

Our concluding section on Coasian dynamics and information leakage illustrates the potential gains from connecting substantively disparate fields. Returning to Wagner's claim that strategic signaling is not central to the conflict domain we see that he is correct in the limit. For a fixed time between offers, the uninformed proposer can learn about the other player's type from her bargaining behavior (even if there is no learning from the battlefield). This argument is a challenge to Wagner's perspective and a re-statement of a point that Powell makes clear. But as the time between offers vanishes conflict duration

vanishes (as shown in Powell's proposition 3). But a point not emphasized in the earlier conflict literature but entirely standard in the buyer-seller context is that as this happens learning also vanishes and in the limit the equilibrium settlement makes the weakest type of the uninformed player accept. So Wagner's conclusion is true in the limit. But with mechanical learning from the battlefield, a form of information leakage, we can draw on extant work in the buyer seller case and our equivalence result to see that here conflicts may last longer and both types of learning do happen⁴. Thus the presence of learning from the battlefield makes it possible to also learn by observing how an opponent negotiates even when the time between offers vanishes. Because the equivalence allows us to rely on a longer-running literature we may more quickly move away from over-interpreting a host of rich but none-the-less focused models. For example Powell and Slantchev and Filson and Werner make choices that render these models poor choices for a study of what happens as frictions vanish, but excellent models to address the points they focus on. In contrast models that are designed for a study of limiting behavior have appeared in other substantive fields. Moreover, the equivalence can be used to develop interesting contrasts. For example as discussed in a remark below, assumptions about the informational environment that may seem natural in the conflict setting are quite different than ones that may seem natural in the buyer-seller context.

2. The Intuition for the Equivalence

The intuition for our main result connecting the two classes of models can be seen by first considering a stark two period model in which a seller can make a price offer to a buyer in period 1 and if the offer is rejected she can make a new offer in period 2. In such a model, when the buyer's valuation, v of the item is private information and player's are impatient, we know that screening can happen. Suppose that the seller posts a high price p_h in period 1 and following rejection is expected to post a lower price p_l in period 2. In this case the benefit from rejecting the first offer and accepting the second offer is given by

$$[\delta v - p_l] - [v - p_h]$$

This gain is positive if

$$v < \frac{[p_h - p_l]}{1 - \delta}$$

In particular buyers that place high value on the item would want to accept immediately and buyers that place lower value would want to delay. This is the calculus of single-crossing that allows for delay to screen the buyer's type. If instead we consider a stark model from International relations where two parties negotiate over territory with war as an outside option we see a very different calculus. In this approach the countries negotiate and if negotiation breaks down they fight obtaining value w (which is often considered private information) from conflict. In this class of models the benefit from rejecting the initial poor offer, which has value x_l , and continuing negotiations to accept a second more attractive offer of value x_h is given by

$$\delta x_h - x_l$$

Importantly, the decision to delay does not depend on the private information about the value of war if the players are going to eventually settle and thus avoid conflict. The former is a two period version of Fudenberg Levine and Tirole and the latter is an extension of Fearon's take it or leave it game to allow a second offer. In light of the inability to obtain single-crossing or screening from delay in the second example, it is not surprising that some political scientists have argued that talk is cheap and direct information from seeing the battlefield is needed. But, this conclusion is premature. If instead we consider a stark two period model in which war is the inside option (so that the parties fight until a settlement is reached) we see that single-crossing may be satisfied. Here the benefit from rejecting

the first, poor offer and continuing to fight a period and then eventually accepting a better offer is given by

$$w + \delta x_h - x_l$$

This gain is positive if

$$w > x_l - \delta x_h$$

and once again players who derive higher payoff from fighting will be more inclined to delay and players that suffer more from fighting will be less inclined to delay.

Given this simple comparison it is not difficult to see that a large class of models of bargaining with war as an inside option are equivalent to a large class of models of bilateral trade.

3. Equivalence

3.1. Environments

Our goal here is to build off the logic in the above example and work with a set of environments that is rich enough to include models well suited for studying a range of questions. Of, course one can conceive of natural models that fall outside these classes, but we hope the basic intuition contained here will help guide others to see the potential for these kinds of connections even if the direct result does not apply to the relevant model. We focus only on connections between conflict and buyer-seller models and do not directly solve or analyze any games. We close by drawing on extant findings from more concrete analysis of particular games in these classes. We begin by defining two classes of models. As mentioned our goal is not to define the largest possible classes, but rather to specify sets large enough to allow for a variety of different contexts. Each is a two player infinite horizon game in discrete time. The first, a bargaining while fighting game involves two disputants, state 0 and state 1 and begins with a conflict. While fighting each player receives flow payoff $w_i(\theta_i, \theta_{-i})$ which depends on the types $\theta_0 \in \Theta_0$ and $\theta_1 \in \Theta_1$. We assume that the joint distribution $F(\theta)$ is common knowledge. At the beginning of the game each player learns her own type. A bargaining protocol P is a random recognition rule determining which player can make a proposal at every possible period t if the game does not terminate prior to period t . Formally it is a joint distribution on the set of sequences of 0's and 1's. We let $p_t \in \{0, 1\}$ denote the realized identity of the proposer in period t . Accordingly, we are agnostic about dependencies of the identity of the proposer across periods. If player i is recognized at period t she may make an offer x from the set $X \subset R_1$. Player $-i$ then may either accept or reject the offer. If the offer is accepted the game ends and the terminal history is described by the pair (x, t) . If the offer is rejected then the game continues to period $t + 1$ and player p_{t+1} is the new proposer. If the game ends at terminal history (x, t) , each player's flow payoff in period t and all subsequent periods is given by $u_i(x)$. We assume that each player has time value δ_i . Thus, payoffs from (x, t, θ) are of the form

$$U_i(x, t; \theta) = \frac{1 - \delta_i^t}{1 - \delta_i} w_i(\theta_i, \theta_{-i}) + \frac{\delta_i^t}{1 - \delta_i} u_i(x)$$

To capture the idea of bargaining over an efficient frontier we assume that $u_0(\cdot)$ is increasing and $u_1(\cdot)$ is decreasing. For example x could be the share of territory that 0 keeps and $1 - x$ the share that 1 keeps after a settlement and we might assume that $u_0(x) = x$ and $u_1(x) = 1 - x$. Alternatively, we might think of x and set the status quo at 0 with nation 0 preferring an increase in policy and nation 1 preferring a decrease in policy, $u_0(x) = x$ and $u_1(x) = -x$.

The second class of modes represents a generalization of those in Fudenberg, Levine and Tirole (1985) [2]. For lack of a better term we call it a buyer-seller game. Two players, seller, 0, and buyer, 1 negotiate over the possible trade of an indivisible item from seller to buyer. For every period in which i owns the item he derives flow payoff $v_i(\gamma_i, \gamma_{-i})$ with $\gamma_i \in \Gamma_i$. We assume that the joint distribution $G(\gamma)$ is common knowledge. At the

beginning of the game each player learns her own type. With no loss of generality we normalize the flow payoff to not owning the item to 0 for both players. A bargaining protocol P is random recognition rule determining which player can make a proposal at every possible period t if the game does not terminate prior to period t . Formally it is a joint distribution on the set of sequences of 0's and 1's. We let $p_t \in \{0, 1\}$ denote the realized identity of the proposer in period t . Accordingly, we are agnostic about dependencies of the identity of the proposer across periods. If player i is recognized at period t she may make an offer y from the set $Y \subset R^1$. Following this offer player $-i$ may either accept or reject the offer. If the offer is accepted the game ends and the terminal history is described by the pair (y, t) . If the offer is rejected then the game continues to period $t + 1$ and player p_{t+1} is the new proposer. If the game ends at terminal history (y, t) the flow payoffs in period t and in all future periods are given by $v_1(\gamma_1, \gamma_0) + h_1(y)$ for the buyer, 1, and $h_0(y)$ for the seller, 0. Note that the offers's y are interpreted as annuities that yield flow payoffs of $h_i(y)$. One could rescale to capture the case of a one-time payment. We assume that each player has time value r_i . Thus the payoffs from (y, t, γ) are

$$V_0(y, t; \gamma) = \frac{1 - r_0^t}{1 - r_0} v_0(\gamma_0, \gamma_1) + \frac{r_0^t}{1 - r_0} h_0(y)$$

$$V_1(y, t; \gamma) = \frac{r_1^t}{1 - r_1} v_1(\gamma_1, \gamma_0) + \frac{r_1^t}{1 - r_1} h_1(y).$$

To capture the idea of bargaining over an efficient frontier we assume that $h_0(\cdot)$ is increasing and $h_1(\cdot)$ is decreasing. So for example we could think of y as the price paid once and $h_0(y) = (1 - r_0)y$ and $h_1(y) = -(1 - r_1)y$ as the stream of value associated with receiving/making this payment in the current period.

In order to define a bargaining game in either the first or second class we need only to augment our current concepts with an informational environment. Let S_i denote a signal space from which player i in the first class of games observes a signal in any possible period and let C_i denote the space in the second class of games. By s_i^t and c_i^t denote realizations of these signals. We require that these signals include any information players may observe about their own payoffs. So in particular if player i observes the value of $v_i(\gamma_i, \gamma_{-i})$ at period t then this information is contained in c_i^t .

An informational environment is then a pair of joint distribution on the types and sequences of signals, $(\Theta_1 \times \Theta_2 \times S_1 \times S_2 \times S_1 \times S_2 \dots)$ in the first class and $(\Gamma_1 \times \Gamma_2 \times C_1 \times C_2 \times C_1 \times C_2 \dots)$ in the second class. Given an informational environment in the first class the conditional probability over θ_{-i} given a finite list of signals, $\bar{s}_i^t = (s_i^1, s_i^2, \dots, s_i^t)$ and θ_i as $F(\theta_{-i} | \bar{s}_i^t, \theta_i)$ is well-defined. Similarly, given an informational environment in the second class, $G(\gamma_{-i} | \bar{c}_i^t, \gamma_i)$ is well-defined.

3.2. Result

Our main result establishes an equivalence between games in the two classes. While the notion of equivalence between games involves subtleties (see for example Battigali, Leonetti and Maccheroni (2020) [7] and the cites within) our usage is rather direct. We show that for a model of conflict in the class described above there is an equivalent model of trade in the class described above and the mapping connecting one model to its equivalent involves only re-labeling of actions, signals and types and affine transformations of the the Bernoulli utility functions. As, such all we rely on is Von Neumann and Morgenstern's Theorem. This notion of equivalence goes in both directions and so for any model of trade the inverse of the mapping obtains an equivalent model of conflict. Because our mapping involves an affine transformation of Bernoulli utility functions the best responses of one model coincide with those of its equivalent model in the other class. In particular for any bargaining while fighting game defined above there is some buyer-seller game in which the best responses at each information set and equilibrium sets coincide and conversely for every buyer-seller game defined above there is a bargaining while fighting game in

which the equilibrium sets as well as best responses at each information set coincide. To establish the result we identify a simple mapping that converts the primitives of a game in one class to primitives in the other class while preserving every possible comparison of lotteries over terminal histories at all information sets. Our exposition is slightly tedious but the analysis involves only making the appropriate connections to capture the intuition from the above exercise.

Theorem 1. *For any bargaining while fighting game (as defined above) there is some buyer-seller game which is strategically equivalent. For any buyer seller game (as defined above) there is some bargaining while fighting game which is strategically equivalent. Moreover, the following transformation works. Set $\Gamma_i = \Theta_i$, identify, $F(\cdot) = G(\cdot)$ and equate the informational environments.*

$$r_0 = \delta_0, v_0(\cdot, \cdot) = w_0(\cdot, \cdot), h_0(\cdot) = u_0(\cdot)$$

$$r_1 = \delta_1, v_1(\cdot, \cdot) = -w_1(\cdot, \cdot), h_1(\cdot) = u_1(\cdot)$$

Proof. Take as given some bargaining while fighting game as described above: A terminal history of a bargaining while fighting game is defined by (x, t, θ) and a terminal history of a buyer-seller game is defined by (y, t, γ) . We will construct a buyer seller game with $y = x, \gamma = \theta, \Gamma_i = \Theta_i, G(\cdot) = F(\cdot), C_i = S_i$.

Step 1 is to define an affine translation of player 0's payoffs (in the bargaining while fighting game) that make her the seller, 0, in the buyer-seller game. Player 0's payoffs in the bargaining while fighting game are

$$U_0(x, t; \theta) = \frac{1 - \delta_0^t}{1 - \delta_0} w_0(\theta_0, \theta_1) + \frac{\delta_0^t}{1 - \delta_0} u_0(x)$$

In order to convert these payoffs to the form of player 0 (seller) in the buyer seller game,

$$V_0(y, t; \gamma) = \frac{1 - r_0^t}{1 - r_0} v_0(\gamma_0, \gamma_1) + \frac{r_0^t}{1 - r_0} h_0(y)$$

it is sufficient to set $r_0 = \delta_0, v_0(\cdot, \cdot) = w_0(\cdot, \cdot), h_0(\cdot) = u_0(\cdot)$.

Step 2 is to define the translation for player 1. Player 1's payoffs in the bargaining while fighting game are of the form.

$$U_1(x, t; \theta) = \frac{1 - \delta_1^t}{1 - \delta_1} w_1(\theta_1, \theta_0) + \frac{\delta_1^t}{1 - \delta_1} u_1(x)$$

Consider now a fictional player 1' with type θ_1 who's payoffs are the following affine transformation of player 1's. Player 1' Bernoulli utility function is $w_1(\theta_1, \theta_0)$ less than player 1's at every period.

We then obtain

$$U_{1'}(x, t; \theta) = \frac{\delta_1^t}{1 - \delta_1} (u_1(x) - w_1(\theta_1, \theta_0))$$

This is identical to the structure of 1's payoffs in the buyer seller game. Since sequential rationality for player 1 and player 1' are satisfied at exactly the same choices (at every informational environment and belief) it is sufficient to set $r_1 = \delta_1, v_1(\cdot, \cdot) = -w_1(\cdot, \cdot), h_1(\cdot) = u_1(\cdot)$.

Finally, with equivalent informational environments the first result obtains. To move in the other direction it is sufficient to use the same translation and observe the identities above.

□

Remark 1. *A natural interpretation of the transformation to player 1's payoffs is that in the equivalent buyer seller game the buyer is buying an item that provides her value equal to the difference between her payoff from the settlement and her payoff from fighting. That is, she is buying a stream of value equal to the gains from settling the conflict at terms x . The seller's least preferred*

type in the buyer seller game has the lowest valuation to owning the good. This type corresponds to the type of player 1 with the highest war payoff.

Remark 2. Equating the informational environments is not innocuous. In particular, for non private values cases this result will show that equivalent buyer-seller games can be difficult to interpret. If in the bargaining while fighting game players observe their war payoffs while fighting then in an equivalent buyer seller game the buyer needs to observe a signal of what her payoffs from consumption would be. If in the bargaining while fighting case, learning one's own war payoff provides information about the other player's war payoff then in an equivalent buyer-seller game when the seller consumes the item for one more period she learns more about the buyer's valuation. Similarly, if the buyer learns about her potential valuation prior to trade then she would also be learning about the seller's valuation. These connections can be justified, but we recognize they are not innocuous. With independent private values this is far less demanding as there is no informational value to learning one's own payoff given that one knows her own type. It is important to note that our treatment is innocuous as to whether information leakage occurs, the classes considered certainly allow for it. In concrete terms, learning only about your own payoffs from fighting from experience on the battlefield corresponds to learning only about your own valuation of the item for sale. Learning about the other player's payoffs corresponds to learning about the other player's valuations. Some conflict studies papers, (like Powell 2004 [5]) involve an equivalence between learning about power and observing hard signals about both players war payoffs.

4. An Application: One-Sided Private Information

To illustrate the value of our equivalence and gain some traction on the running debate in Wagner and Powell we consider a stark example with one sided private information (as in Filson and Werner 2002) about warfighting payoffs. Suppose that the flow payoff to fighting is $p - k$ to player 0 and $1 - p - c$ to player 1. p, k are common knowledge and c is private information of player 1. Let c be drawn from $F(\cdot)$ on $[\underline{c}, \bar{c}]$. The game begins with the players fighting and until an offer is accepted offers of $x^t \in [0, 1]$ are made. The flow payoff from an accepted offer is x to 0 and $1 - x$ to player 1 in all future periods. Assume the players have common discount rate δ . Wagner and Powell and Slantchev and Filson and Werner all analyze different models but there is enough similarity between there settings and this stark example that the connections should be clear. Importantly, relying on the connections with extant work in the buyer seller context we are able to reach conclusions about what happens when time frictions vanish and the type space is rich. This is not true of the analysis in the above cited models.

We may apply Theorem 1 above and consider an equivalent buyer-seller game. The seller, player 0, obtains a flow payoff of $p - k$ from consumption of the item in each period until trade occurs and the buyer obtains a flow payoff of $-1 + p + c$ from owning the item after trade. Bargaining is over price, x and the seller obtains a flow payoff of x from trading at price x while the buyer obtains a flow payoff of $1 - x - 1 + p + c = p + c - x$ from trading at price x . The so-called gap case that Fudenberg, Levine and Tirole discuss then involves $p + c > p - k$ or $c + k > 0$ for all $c \in [\underline{c}, \bar{c}]$. The gap case thus involves the ordering $\underline{c} + k > 0$.

Remark 3. Thus as long as war is strictly inefficient with probability 1 we are in the gap case and the results in Fudenberg, Levine and Tirole apply to the corresponding buyer-seller model.

Uninformed Player Makes all Offers

The case where the uninformed seller makes all the offers is well-studied. By way of the equivalence this case is the same as one where the uninformed party makes all the offers. Fudenberg, Levine and Tirole show that for the gap case the equilibrium is unique and as the delay between offers vanishes the seller sells at the valuation of the lowest type buyer. More precisely, in the limit the item is sold immediately and the buyer keeps all the possible informational rents. This result is typically identified as the Coasian logic and

corresponds to the important insight that commitment to make a take it or leave it offer is optimal for the seller. Reducing the time frictions does not upset this conclusion. In the IR context then we see that if the uninformed player reserves monopoly power over making offers then as the time between offers vanishes the duration of fighting vanishes but the rents to this monopoly proposing power also vanish. What then does this result say about bargaining in conflict? The result is rather stark. Learning does not happen but conflict duration is short. In a model in which there is no direct channel for learning from the battlefield if the frequency of offers is high enough conflict duration vanishes and the uninformed player will not learn.

What happens if there is direct learning from the battlefield (as in the previously cited IR papers). Powell looks at the case of private information about strength only in a model in which the information is revealed after any period of fighting. If we move to smoother models where partial learning can occur in each period (or learning is random) we may rely on buyer-seller models with leakage. Madarasz (2021) [8] introduces the possibility that players may have miscalibrated beliefs about leakage (in our setting we may use the equivalence to interpret this leakage as arrival of information from the battlefield). Madarasz provides a survey and highlights the following conclusion. If the players have common knowledge of the leakage then in general the Coasian dynamics are partially reversed. Delay persists as the uninformed player waits for information leakage. This means that learning from the battlefield will slow bargaining and cause conflicts to be longer but the uninformed monopolist proposer will eventually extract rents. On the other hand if the informed player is pessimistic and believes that information leakage is faster than it actually is then Coasian dynamics are fully reversed. As the time between offers vanishes the proposer is able to learn more and in the limit settlement occurs quickly (war duration is low) and settlements reflect full rent extraction from the informed player to the uninformed player.

5. Discussion

The study of conflict relies heavily on the development of ever-richer models of bargaining with asymmetric information. But despite this progress models by definition tend to be stylized and thus learning about the full range of models can take time. We have made two contributions, one technical and one substantive. By connecting the canonical problem of conflict studies with a canonical problem in economic theory and providing an equivalence at a reasonable level of generality we hope to help future scholars see deeper connections between these two bodies of work. This will hopefully speed up the rate at which each field gains deeper understanding about the problem. We see room for progress on studies of information leakage and projection (Madarasz 2021) [8] or work on dynamic mechanism design (for example Pavan, Segal and Toikka 2014) [9]. Connecting this work with conflict by way of the equivalence result established here may provide sharp dividends to scholars of conflict studies. Of course the direction of learning can surely go the other way. It seems likely, for example, that scholarship in conflict studies on the relevance of commitment power by bargainers (Fey, Meiwitz and Ramsay 2017) [10] or mediators (Horner, Morelli and Squintani 2015; Meiwitz et. al 2017) [11,12] or may prove relevant in the study of market design.

Second, in developing this equivalence we bring the long-standing appreciation of learning via screening in classical buyer-seller problems to discussions about the nature of learning from fighting in conflict studies. Our take-away is that while we don't agree with the argument that only hard information from the battlefield matters, insights about how Coasian dynamics depend on assumptions about the informational environment show that learning from fighting may in fact rest primarily on what is learned on the battlefield as opposed to what is learned from observing the strategic choices at the negotiations table in some cases. Whether this causes conflicts to remain long or not seems to depend on the extent to which players have common knowledge of the informational environment. We see utility in the equivalence result as it allows us to draw on work in other areas to

see how learning from the battlefield may in fact crowd out strategic inference and lead to longer wars. We anticipate insights might be reached by drawing on extant work in behavioral economics to see how this might depend on the level of calibration of players understanding of the informational environment.

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Notes

- ¹ Both channels of learning can be found in the equilibria of these papers.
- ² Powell's focus was on the similarities and differences between models in which uncertainty about war payoffs relate to costs or strength, the former cases of private values and the latter cases of interdependent values. We treat both cases and show that the choice to treat war as an inside option or an outside option determines whether the conflict model is strategically similar to a buyer-seller model.
- ³ One might then draw connections with work in economics and possibly gain analytical traction. For example one may work on richer variants of the model in Filson and Werner 2002 [4].
- ⁴ Powell's proposition 4 is based on a model with learning on the battlefield that has a stark informational assumption. And so full learning can occur after only one period on the battlefield.

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