Contracting Problems and the Technology of Trade: A Robustness Result with Application to Hold-Up

Kristy Buzard and Joel Watson

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The hold-up problem arises in situations in which contracting parties can renegotiate their contract between the time they make relationship-specific investments and the time at which they can trade. Consider a model of trade between two parties who have the opportunity to write a contract specifying the terms of trade. After writing a contract, one party chooses a level of investment, which is observable to the other party but not verifiable to the external enforcer. This investment influences the "state" of the relationship, which affects the surplus created by any trade that takes place subsequent to the investment being made. Next the parties can renegotiate their contract. Following this "interim" renegotiation, the parties send public messages to the external enforcer and then can renegotiate a second time. After this "ex-post" renegotiation takes place, the parties have the opportunity to trade. Finally, an external enforcer (such as a court) enforces the contract.

If the parties cannot write an enforceable contract that is contingent on the investment decision, the party who does not have the investment action can extract concessions from the investing party under the threat of blocking trade. Anticipating this hold-up, the level of investment that is chosen ex ante may not be optimal. Many authors have analyzed the severity of hold-up in various contractual settings. For instance, hold-up has been found to be particularly serious in settings with cross-investment, when the investment directly affects the valuation of trade for the non-investing party.[1] However, because prominent models make quite disparate assumptions, it is difficult to make comparisons.

Watson (2007)[2] shows that essential differences between various models in the literature lie in the modeling of the actions that consummate trade. The key issue is whether the trade action is modeling as public or individual. Public-action models abstract from the account of individual trade actions by considering them as taken directly by a third-party enforcer as directed by the messages sent by the trading parties. Technically, modeling individual trade actions as public is equivalent to restricting attention to "forcing" contracts, which rule out using individual trade actions as options.

The analysis is carried out by examining the set of implementable values as a function of the state under various assumptions about when renegotiation is possible and how trade

[1] In general, the literature is in agreement that hold-up does not create a significant problem in the case of self-investment.

[2] Watson, J. (2007): "Contract, Mechanism Design, and Technological Detail," *Econometrica*, 75, 55-81.

actions are modeled. Let V^I and V^{EPF} be the sets of implementable value functions for the public-action model under interim and ex-post renegoitation, respectively. Further, let V^{EP} be the set of implementable value functions for the individual-action model with ex-post renegotiation.[3] Watson (2007) characterizes these three sets and uses an example to show that $V^I \neq V^{EP} \neq V^{EPF}$ in general. Watson's results indicate the importance of modeling trade actions as individual and, more broadly, highlights the critical connection between the technology of trade and the severity of the hold-up problem.

In this paper, we examine the robustness of Watson's example and provide general results showing that the inequalities $V^I \neq V^{EP} \neq V^{EPF}$ hold for a wide range of contractual settings. In fact, with a minimal amount of structure along the lines of what is typically assumed, every contractual setting has this property and so one must model the trade action as individual in order to correctly characterize the set of implementable value functions for a wide array of settings. Further, we provide simple tools that allow the researcher to easily calculate the "punishment values" that determine the implementable sets.

The key economic assumption we make is that the utility function of the player who takes the trade action exhibits supermodularity; that is, this player's marginal value of the trade action is monotone in the state. For simplicity, we assume that only one player takes a trade action, although the result generalizes to settings in which both players do. The remaining assumptions are weak technical conditions that guarantee the utility functions are well-defined, have unique maxima and are non-trivial. These conditions will hold in a wide range of models and applications.

Our main result implies that modeling actions as individual will almost always expand the set of implementable value functions. However, this does not mean that a more efficient outcome can always be achieved when actions are modeled as individual; this is because efficient implementation depends on what region of the implementable values set is needed for giving appropriate investment incentives. That is, in some examples, $V^{EP} \neq V^{EPF}$ but they coincide where it matters to induce optimal investment. For instance, the literature has shown that forcing contracts (public-action models) are sufficient to achieve the first best in the case of self-investment. The case of cross investments is more complex and this is where the current debate about hold-up is centered. In a setting with durable trading opportunities, Evans (2008) claims that contracting can resolve the hold up problem even in the presence of cross-investment; however, this result relies on the assumption that it is feasible to create a "financial hostage" in order to influence the shares of surplus that the parties get in renegotiation. Watson and Wignall (2009) also examine the set of implementable value functions for the durable trade opportunities setting and show that the technology of trade is an important determinant of when the hold-up problem occurs in cross-investment

[3]Watson (2007) shows that in settings where parties can renegotiate only at the interim stage (after the state is realized but before sending messages to the external enforcer), individual- and public-action models are equivalent. We therefore do not separately analyze the sets of implementable value functions in these two models and refer to them both as V^I.

environments.

In a similar spirit in our setting of non-durable trading opportunities, we show that expanding the class of allowable contracts to include non-forcing contracts will generally alleviate the hold up problem when the party who chooses the trade action and the party who chooses the investment are distinct. In contrast, when the same party chooses both the investment and the trade action, the addition of non-forcing contracts does not necessarily expand the implementable set in a way that allows the efficient outcome to be implemented. We conclude that, although the implementable set under ex-post renegotiation is generally larger when one models trade actions as individual instead of public, the additional implementable outcomes do not necessarily include the efficient outcome and so hold-up remains an obstacle to efficient implementation for some classes of trade technologies.