Coordination in Procurement: An Experimental Study

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1. Introduction

Most of the studies in operations management literature focus on coordinating different stages of a supply chain (e.g., a supplier and a manufacturer) and try to incentivize these parties by designing some form of a contract between them; see e.g., Cachon and Lariviere (2001), Özer and Wei (2006).

In this study, we try to address the coordination issue between several suppliers each supplying a different component of an end-product to a manufacturer. Suppliers must privately decide their respective effort investments in the production process of the component. The production process of the end-product exhibits weakest-link property, i.e., it is restricted by the minimum supplier effort (e.g., capacity, quality, time). We assume that the effort investment by a supplier is unobservable and non-contractible. In such a situation, since effort is costly and investing a higher effort than the minimum of other suppliers will result in losses, suppliers have an incentive to under-invest. On the other hand, collectively, under-investing restricts the profit that can be earned, and again results in losses for the suppliers.

There are two main features of the weakest-link structure that we consider in this study. First, any *common* effort investment is a Nash equilibrium. Second, equilibrium of lower effort investments are pareto dominated by equilibrium of higher effort investments. Thus, achieving the highest effort equilibrium is the most efficient (pareto-optimal) equilibrium in this setting.

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Accordingly, we define the term “coordination” as ending up with any equilibrium (i.e., the selection of homogenous effort choices within a group of suppliers). If suppliers coordinate on the highest (resp., lowest) effort equilibrium, we refer this case as coordinating on the most efficient (resp., least efficient) equilibrium. In this setting, two main issues can arise: suppliers may fail to coordinate on any of the Nash equilibrium (and thus regret their individual effort choices) or given that they have coordinated on some equilibrium, they may not coordinate on the most efficient one.

The production process of Boeing for 787 Dreamliner exemplifies a similar situation (see, Tang and Zimmerman (2009) for details). Boeing has multiple suppliers who will design and build entire sections of the plane and ship them to Boeing. The incapability of some suppliers to develop their sections on-time will delay the entire development schedule. To incentivize its suppliers, Boeing instituted a risk sharing contract under which no suppliers will receive payment (for the development costs) until Boeing delivers it’s first 787 to its customers. The potential of being penalized unfairly when a supplier completes its task before others may create an incentive for this supplier to work slower which may further cause delays in the production. Eventually, Boeing announced several delays for 787 Dreamliner.

In the operations management literature, there is a group of papers which discuss contractual agreement between a manufacturer and multiple suppliers, see e.g., Baiman, Netessine, and Kunreuther (2004) and Li, Duenyas, and Iravani (2011). Different from their approach, our interest in this study is to design a mechanism which induces suppliers to coordinate on the most efficient equilibrium without any contracts, since contracts may not be adequate in some cases such as the Boeing example. To this end, we wonder whether introducing a small amount of

entrance fee can be used as a signal of suppliers' willingness to coordinate, and thus induce them to coordinate on the most efficient equilibrium.

In the experimental game theory literature a similar concern arises in coordination games where the actions of the minimum effort player determine the payoffs to all other players (Van Huyck, Battalio, & Beil, 1990).

We note that the consideration of a weak-link structure corresponds to a scenario in which efforts are perfect complements. There may be some other settings which face coordination problems in less severe settings, however understanding and finding a solution to overcome a coordination failure in a severe setting would shed light on problems in more forgiving situations.

2. The (Weakest-Link) Model

Let $N = \{1, 2, \ldots, n\}$ be a group of suppliers and $E = \{1, 2, \ldots, k\}$ denote their set of effort investments. Each supplier i privately decides her effort investment $e_i \in E$. The payoff of supplier i is given by

$$\pi_i = \alpha \min_{j \in N} \{e_j\} - b\, e_i + c \qquad \text{where } \alpha > b > 0$$

In this setting, any common effort investments is a Nash equilibrium. Thus, the best response for a supplier is to match the lowest effort investment of everyone else, i.e.,

$$e_i = \min_{j \in N} \{e_j\}$$

Note that the payoff of supplier i is a decreasing function of her own effort investment and an increasing function of the minimum effort investment of all n suppliers. A player has an incentive to raise her effort investment if and only if it will increase the minimum of the effort investment of all suppliers.

3. Experimental Design

We plan to run two experiments: (i) baseline treatment, and (ii) main treatment (in which we introduce a fee to become one of the suppliers).

Two experiments will have the same general setup, use incentive-compatible payoffs to encourage subjects for careful decision making. Our human subjects, who are in the role of suppliers, must decide their respective effort investments in the production process of the component. Subjects play the game for 25 decision rounds in fixed groups. We chose to have repeated interactions to allow participants to learn to coordinate. As a practical matter, we only provide the minimum effort investment chosen by suppliers to our subjects, since monitoring of the actions of their fellows may not be possible in many cases.

For the baseline treatment, we plan to have 10 groups, with $n = 4$ participants.

The main treatment will occur in two stages. The fee will be introduced in the first stage and the second stage will continue with the participants who pay the fee in the first stage.

We are currently working on the design details for the experiments.

4. Future Work

We plan to finalize the design details in couple of weeks and continue with running the experiments in laboratory.

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