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Invited research paper

Fairness in supply chain contracts: A laboratory study

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ABSTRACT

Various contracts can be designed to coordinate a simple supplier–retailer channel, yet the contracts proposed in prior research and tested in a laboratory setting do not perform as standard theory predicts. The supplier, endowed with all bargaining power, can neither fully coordinate the channel nor extract all of the channel profit. We report on a sequence of laboratory experiments designed to separate possible causes of channel inefficiency. The three causes we consider are inequality aversion, bounded rationality, and incomplete information. It turns out that all three affect human behavior. Inequality aversion has by far the most explanatory power regarding retailers' behavior. Incomplete information about the retailer's degree of inequality aversion has the most explanatory power in regards to the suppliers' behavior. Bounded rationality affects both players, but is of secondary importance.

1. Introduction

The field of Supply Chain Management (SCM) draws upon a number of disciplines, such as sourcing, logistics, operations, marketing, information systems, and management (Chen and Paulraj, 2004). While each of these disciplines focuses on a separate aspect of SCM, they mostly agree in that the essence of SCM is coordination among separate independent firms. Coordination efforts focus on and derive benefits from "... information sharing, goal congruence, decision synchronization, incentive alignment, resource sharing, collaborative communication, and joint knowledge creation." (Cao and Zhang, 2011, p.61). It is well-known that contracts that fail to align incentives of independent, self-interested firms comprising a supply chain, are one of the biggest causes of suboptimal performance (Narayanan and Raman, 2004).

There is a good deal of analytical modeling literature in operations, starting with Spengler (1950), that deals with designing contracts to align incentives and coordinate channels (Cachon, 2003). The empirical evidence obtained in the laboratory tests of coordinating contracts, however, demonstrates that coordinating contracts usually fail to coordinate channels (see Katok, 2011 for a review). These studies report that participants who propose contracts (suppliers) tend to make efficient offers, but participants who respond to those offers (retailers) often reject them. It is those negotiation breakdowns that are the main cause of inefficiency in the laboratory. In fact, negotiation breakdowns are also observed in the real world. In a well-cited example, Fisher et al. (2011) describe a negotiation for natural gas between the US and the Mexican governments that ended in the Mexicans burning off the gas rather than accepting a low-ball offer. Because negotiation breakdowns (rejections) are such a major cause of the inability of coordinating contracts to align incentives in practice, understanding their cause is an important step toward designing better-performing contracts.

We use laboratory experiments to investigate the cause of rejections in the laboratory. Our work is part of the Behavioral Operations Management (BOM) literature (Loch and Wu, 2008; Bendoly et al., 2006, 2010; Gino and Pisano, 2008). This literature has its roots in cognitive psychology (Thurstone, 1927; Simon, 1955, 1957; Kahneman and Tversky, 1979) and experimental economics (Kagel and Roth, 1995, Camerer, 2003, Bardsley et al., 2010).

Our main hypothesis is that preferences for *fairness* (also referred to as *inequality aversion*) are the main cause of rejections. Liu et al. (2012) identify four dimensions of fairness (or justice) relevant in supplier–buyer relationships: *distributional*, *procedural*, *interpersonal*, and *informational.* Our study focuses on the distributional aspect of fairness. Fairness has been long recognized as one of the most important factors guiding human interactions in everyday life (Adams, 1965 as well as in business Kahneman et al., 1986; Griffith et al., 2006; Kumar et al., 1998; Scheer et al., 2003). It is closely related to other-regarding preferences, such as status, altruism, reciprocity, so common in the everyday life of individuals, which also play an important role in the corporate environment. In project management, requests to share a resource tend to be accommodated even when this is counter-productive both for the person sharing the resource and the overall firm performance (Bendoly and Swink, 2007). Workers, when paid at a different rate from their peers, tend to adjust their outputs quality/quantity in

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a way that mitigates inequity between their pay and that of other workers (Goodman and Friedman, 1971). In the automobile industry, punitive behavior is not uncommon toward a supply chain partner whose actions are perceived to be unfair (Kumar et al., 1998).

Two streams of BOM literature are most closely related to our work. The first stream investigates the role of other-regarding preferences, such as fairness, on the performance of the wholesale-price contract. Cui et al. (2007) develop a model in which both parties care about fairness in a bilateral monopoly setting with a supplier and a retailer, and characterize conditions under which the supplier can coordinate the channel using wholesale pricing. Loch and Wu (2008) report on a set of laboratory experiments that show that wholesale price contract fails to coordinate the channel even after participants have been primed for cooperation. Katok et al. (2012) extend the Cui et al. (2007) model to include incomplete information. Ho et al. (2012) extend the model to a setting with multiple retailers and add peer-induced fairness.

The second literature stream investigates the performance of coordinating contracts. Ho and Zhang (2008) compare two mathematically equivalent contracts—two-part-tariff (TPT) and quantity discount contracts—and show that rejections are significantly higher under TPT. They show that a model that includes loss aversion can account for the reported treatment effect. Haruvy et al. (2012) investigate the TPT contract under different bargaining protocols, and find that a richer bargaining environment improves efficiency. Lim and Ho (2007) study 2- and 3- block tariffs and find that 3-block tariffs perform better in the lab even though in theory they should not. They attribute the treatment effect to counterfactual payoffs.

Neither of the two streams of the BOM literature we mentioned above, however, directly investigates the cause of rejections. Pavlov and Katok (2011) develop a model of coordinating contracts with fairness preferences, and their major finding is that rejections result from incomplete information about fairness preferences. Intuitively, if the supplier knows the extent to which the retailer dislikes inequality, she can offer the retailer a contract that this retailer would (just barely) accept. However, if the supplier does not know the specific retailer's preferences, some (highly inequality averse) retailers will reject the optimal contract.

The research question we address in this paper is to what extent inequality aversion, incomplete information about inequality aversion of other players, and errors (caused by factors other than fairness and incomplete information about it), exist in a laboratory contracting setting, and how they affect contract performance. Specifically, we measure the relative importance of these three factors. The main challenge we face is that the extent to which people dislike inequality and are prone to errors is, in fact, their own private information; it is part of their personality. And while there may be ways to measure some of these individual attributes (with survey instruments and hypothetical experiments, for example) these measures may well be confounded when combined with having participants play the contracting game. Therefore, we take a radically different approach, and design a unique and innovative experiment to directly get at the issue of incomplete information and error-making.

The essence of our design is to start with a treatment with two human players, use the retailers' decisions in this treatment to model their inequality aversion and propensity to make errors, and then conduct a sequence of additional treatments with automated retailers programmed to behave like their human counterparts. In these additional treatments we manipulate the extent to which retailers are prone to make random errors and, most importantly, the amount of information the supplier has about the specific retailer with whom she is matched. Neither of these experimental manipulations is possible with human retailers, thus our design provides a clean test that we use to separate and measure the effect of behavioral factors on contract performance.

In Section 2 we present the key aspects of the basic model and formulate the research hypotheses. Section 3 details our experimental design and protocol. We present our results in Section 4, and conclude the paper with a summary and discussion in Section 5.

2. Model and hypotheses

2.1. The basic setting with full rationality

We are studying a distribution channel with a single supplier who produces units at a constant production cost of c per unit, and a single retailer. The retailer faces a linear market demand $q = A - p$, where p is the retail price and A is a constant. The supplier proposes a contract to the retailer, and the retailer either rejects the offer, in which case both parties earn zero profit, or places an order for q units. Since the retailer faces deterministic demand and the product has no salvage value, we assume that the retailer's order will match the amount sold, given the retail price.

We say that the channel is centralized if the outcome in terms of units produced is the same as the outcome that would have resulted from a single decision maker maximizing the entire channel profit. The channel profit to be maximized in the centralized channel is

$$\pi c = (p - c)q = ((A - q) - c)q. \quad (1)$$

The order quantity that maximizes this channel profit is $q^* = (A - c)/2$, yielding the optimal (first-best) channel profit of $(A - c)^2/4$.

If the channel is not centralized—the two firms optimize separately and independently—we consider a wholesale-price contract in which the retailer pays the supplier w per unit and the retailer determines the order amount q. The retailer maximizes his own profit by ordering $q^*_{WP} = (A - w)/2$ which is lower than the first-best order quantity q^* whenever $w > c$. The supplier must set the wholesale price so as to maximize his profit

$$\pi_S = (w - c)\, q^*_{WP} = \left(\frac{(w - c)(A - w)}{4}\right) \quad (2)$$

resulting in the profit-maximizing wholesale price $w^*_{WP} = (A + c)/2$. This optimal wholesale-price contract (with profit-maximizing players) results in the supplier's profit of $\pi_S^{WP} = (A - c)^2/8$, the retailer's profit $\pi_R^{WP} = (A - c)^2/16$, and the total channel profit $\pi_C^{WP} = 3(A - c)^2/16$, representing the efficiency of only 75% relative to the first-best channel profit. This inefficiency of the wholesale price contract relative to the integrated system is known as *double marginalization*.

A variety of different contracts can solve the double marginalization problem. They all, in one way or another, induce the retailer to place the first best order. The supplier then extracts some of the channel profit from the retailer. The contract on which we focus is the *minimum-order-quantity* (MOQ) contract, in which the supplier proposes a per-unit wholesale price w and a minimum order quantity $q_{\min}$, and the retailer either rejects the contract or orders $q \geq q_{\min}$. If we assume that both parties only care about maximizing their profits, the supplier should coordinate the channel by setting $q_{\min}$ to the first-best order quantity $q^*_{\min} = (A - c)/2$, and then setting the wholesale price so as to extract the entire channel profit: $w^*_{moq} = (A + c)/2$.

There is a significant amount of laboratory evidence that contracts designed to solve the double marginalization problem do not solve it successfully. It is worth pointing out that the analysis we summarized above, which we refer to as the standard theory, critically depends on three assumptions: