Dynamic supply chain coordination games with repeated bargaining

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ABSTRACT

Coordination in a supply chains may require investment in relationship-specific assets (RSA) including information systems and human resources from all or a subset of the partners. These investments are typically partially non-verifiable, possibly based on internal resources or opportunity costs. A supplier offers a single-price single-period contract to a downstream manufacturer who accepts or turns to a non-strategic outside option. Both parties invest in relationship-specific assets (RSA) accordingly. Using a game theoretic framework of repeated single-period bargaining under asymmetric information and outside options, we show how a supplier may behave opportunistically. We show how this rent extraction threat is mitigated when the manufacturer mis-informs the supplier or hides information from her. As a result of both behaviors, our model explains how supply chain coordination and efficiency are impaired. On a normative basis, we provide the manufacturer with new justifications for both dual sourcing and distorting information. Numerical examples illustrate the results.

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1. Introduction

A supply chain is a network of connected and interdependent organizations mutually and cooperatively working together to control, manage and improve the flow of materials and information from suppliers to end users (Aitken, 1998). There is consensus that supply chain optimization involves emphasis on intra-functional and inter-organizational collaboration, leading to coordination of processes, orders and information in areas such as customer service, production planning, logistics, and capacity utilization. Coordination, in particular, has been a research focus (CSC, 2009). RSA has received intense attention in inter-firm relationship research, and has become an important subject in both marketing channel (Kang, Mahoney, & Tan, 2009) and supply chain management. Asset specificity is mainly researched within the framework of transaction cost economics (Williamson, 1985) and relational exchange theory in which it signals the desire to invest in an endured relationship (Anderson & Weitz, 1992). Most of that research considers that the RSA are the object of an agreement or even a contract between two successive partners in a supply chain with the purpose of increasing the performance of that supply chain and protecting the investor from ex-post opportunistic behavior. This paper does not consider the contracts which can

be set up to coordinate trading between the seller and the buyer. We cover the preliminary evaluation that both must conduct in order to maximize their projected interaction, even before a coordinating contract for their operations can be considered. We are interested here in the 'selfish' investment by the downstream partner which is relationship-specific and primarily enhances the investor's performance.

It is observed frequently in buyer–supplier relationships of very different types of goods and services that RSA are deployed by buyers in absence of agreement or even of knowledge of suppliers. Knemeyer, Corsi, and Murphy (2003) has surveyed the outsourcing practice of logistic services and shown that it involves investments in specific assets and non-retrievable commitments of resources on the part of outsourcing companies. Sucky (2007) point to the trend towards outsourcing logistic activities as support to the argument that large firms are focusing their activities on their perceived core competencies. A classical case is that of steel-makers or electricity-generating utilities using sulphurous or other low-value coals. For coke-making, coal blends are required to have specified ranges of values for volatile matter, ash and sulfur content (Adeleke & Onumanyi, 2007). The blend, which lowers the purchasing cost, is processed in special equipment which scrubs the sulfur content. The RSA consist in this specialized equipment. Ball and Loncar (1991) modeled the demand elasticity for Australian coal to price fluctuations in the medium term taking into account the quality of the coal, overall economic activity and the price of oil (a substitute for coal in thermal energy generation). The conclusion was

that demand was relatively inelastic to price increases in the short but not in the medium or long run which is consistent with the time required by customers to redeploy their RSA to adapt their cleaning processes to accommodate coal from other suppliers.

Supply chain coordination is a process built on gradually fostered trust in combination with adequately designed, financed, deployed and monitored collaboration and information-sharing instruments. Partners invest time, capital and human resources into adjusting their operations to their supply chain partners' corresponding processes eg, by changing and coordinating product and packaging dimensions, information technology (IT) communication protocols, bar codes or radio identification codes, product catalogues, product development platforms, production planning (schedule, detail and systems). However, Kampstra, Ashayeri, and Gattorna (2006) notice that progress towards deeper collaboration and coordination with upstream suppliers and downstream customers is slow and frequently disappointing in practice. The authors cite, among other reasons for failure, the lack of trust, fear of external competition, missing infrastructure and financial barriers for the sharing of resources and gains. In particular the infrastructure standard investments that Kampstra et al. (2006) identify as lagging or missing are relationship-specific eg, the adjustment to a given customer's IT standards has little or no value outside of that supply chain.

We identify three essential characteristics of these investments that influence the ability of the supply chain to achieve coordination. First, the specificity of the investment gives rational reason to fear hold-up (i.e, post-contractual opportunistic action) from the supplier. A recent example is the situation in which Ryanair has found itself when Boeing, sole supplier of planes and technical assistance to the company, decided to increase the price of long-term service contracts (O'Doherty, 2009). In June 2011, partly to escape from this situation, Ryanair signed a cooperation agreement with the Chinese aircraft manufacturer, Comac (Odell, 2011). We are interested in the investment incentives: what matters is the potential exposure to a hold-up.

Second, investments may not be verifiable by the supply chain partner. Moreover, even if the investment is verifiable and well defined, the potential cost sharing among several supply chain affiliations make "open book" procedures ineffective in allocating costs and returns.[1]

Third, the coordination investments are empirically subject to continuous and repeated financial negotiations within the supply chain, often over several product or contract generations (Cf. Kampstra et al., 2006). Hence the truthful revelation of RSA costs may not occur.

In this paper, we address the question of why supply chains fail to coordinate relationship-specific investments by a stylized dynamic dyadic model of a supply chain. Whereas the literature has suggested a range of remedies to the hold-up problem, such as in Hart and Moore (1990) and references below, most work address the problem from one or two of these perspectives. Our contribution, based upon a game theoretic framework, is both positive and normative. From a positive viewpoint, our model explains the delays in supply chain coordination and its elusiveness as well as distortions in rent creation and attribution. The normative contribution takes two different viewpoints. From a decision-making stance, two contributions are presented: (a) the Bayesian updating mechanism proposed for the coordinator may be used under more general settings to inform sequential bidding procedures; (b) dual-sourcing is provided with additional justification on opportunistic behavior grounds to protect against holdup

within an ongoing relationship.[2] From a behavioral stance, our contribution provides a theoretical argument justifying the manufacturer's secrecy or communicating biased information about his RSA costs, independently from his bargaining power.

We first set up a full information centralized benchmark; common information is not only the reference point for efficiency estimations, but may also exist in vertically integrated organizations (a production division and a distribution organization). We then investigate the case where information about RSA cost is private to the manufacturer (he); the supplier (she) only has some prior belief about the cost.

In the following section, we give some elements of related literature on the subject. We present in Section 3.3 the full information case and Section 3.4 covers the case where the supplier is unaware of the investment costs that the manufacturer faces. A numerical instance positions the different tradeoffs in Section 4. We conclude in Section 5.

2. Literature review

The holdup problem under incomplete contracting and asymmetric information has attracted considerable academic attention in economics, marketing and supply chain management (Cachon & Netessine, 2004, chap. 2). The properties of hold-up, asymmetry of information, renegotiation, incompleteness of contracts, switching costs (Klemperer, 1987) and lock-ins have all been investigated (Garcia Mariñoso, 2001). In González (2004), the agent faces a hold-up situation while making a cost-reducing specific investment unobservable by the principal. To escape the hold-up, the agent randomizes the investment whereas the principal offers screening contracts. The models explored as presented in the marketing literature (Farrell & Klemperer, 2007, chap. 31) are often restricted to full-information, two-period settings with endogenous downstream prices for various market organizations. Within supply chain management, several models explore the influence of a supplier's offers on the buyer's decision (Sucky, 2004; Sucky & June, 2006; Esmaeili, Aryanezhad, & Zeephongsekul, 2009); others explore how the supplier can tailor his offers to obtain information private to the buyer (Li, Ritchken, & Wang, 2009). To address the issue of channel inefficiency, a typical approach is to design incentive contracts to provide the downstream partner with flexibility to adapt to volatile demand (Cvsa & Gilbert, 2002; Barnes-Schuster, Bassok, & Anupindi, 2002; Wang & Liu, 2007; Zhao, Wang, Cheng, Yang, & Huang, 2010; Zhao, Ma, Xie, & Cheng, 2013). With this incentive, the whole supply chain gains without compromising any of the supply chain members' profits. In the case where the downstream partner or partners is (are) endowed with operating costs and the possibility to invest, Cho and Gerchak (2005), Plambeck and Taylor (2007) provide several coordination mechanisms for the decentralized chain.

Bargaining Theory is a branch of Game Theory that deals with the bargaining situations between two parties (Wu, 2004, chap. 3). In particular, if the bargaining game is single shot, one may characterize its Nash equilibria. Note that in the above literature, renegotiation does not take place within the model.

Segal and Whinston (2002) provide a survey of mechanism design with renegotiation in settings like the current one, i.e., with hold-up risk and asymmetric information on "selfish investments". In Tirole (1986), the seller obtains an information rent whereas in our model the buyer does not disclose the investment cost to the seller so as to mitigate the hold-up risk in future periods. Hou

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[1] A manufacturer invests in a vertical silo to store a liquid compound which one supplier makes. However, once the silo is there, how is its cost spread among several suppliers who provide equivalent products which can be stored in it?

[2] We wish to distinguish here the case of ongoing transactions between a buyer and supplier who know each other from the case where the dual-sourcing is decided because the buyer incurs a high risk of receiving a "bad offer" or bad service from a unique supplier.