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# Efficient non-cooperative bargaining despite keeping strategic information private

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ABSTRACT

The preferred method for negotiating joint value-added activities, such as e.g. licensing, co-venturing or supply chain expansion, is cooperative bargaining, where agents act rationally and have perfect information, i.e., information sharing occurs. In such settings, however, stronger partner often insist on keeping their valuable information private and thus cooperative bargaining cannot occur due to the lack of information sharing. Though, non-cooperative bargaining is usually assumed to be inefficient. Based on a game-theoretic real options model, we develop a contractual solution that allows the proposer to keep its valuable information private while at the same time motivates the other partner to act in a timely and efficient manner, that is, to be Pareto-efficient.



## 1. Introduction

Traditionally, competition took place between individual companies, but there has been a fundamental change during the last few decades due to the increased use of outsourcing, licensing, merging, and collaboration. Today, competition has shifted from the individual-company level to encompass the entire network of economic value added (Lambert and Cooper, 2000). Apart from increased structural integration of upstream and downstream industry chains by means of mergers and acquisitions (M&A) the proper coordination of ongoing collaboration activities, for example among supply chain partners, is of central concern within the domain of operations research. Consequently, game theory should provide valuable insights in the decision-making regarding a common project of several companies.

However, the bargaining companies do not only have to agree on how profits will be shared among them, but also about the timing of a common project. Recent literature acknowledges that classic net present value (NPV) is static in the sense that it requires agents to make decisions immediately (e.g., Keswani and Shackleton, 2006; Chevalier-Roignant et al., 2011). In contrast, viewing investment as an option right, that is, one has the right to invest but is not obliged to, makes it highly important to discover the optimal timing of an investment. As a result of prevailing uncertainties the investors face a tradeoff between early engagement, which ensures a possible first-mover advantage and allows generating profits early, and a later decision to maintain

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flexibility. This flexibility is important because of the irreversible nature of most strategic investments, i.e. financial commitments are at least partially sunk. They cannot fully be recovered if the project is abandoned at a later stage. Consequently, option-based valuation is a valuable tool to address these issues and has been successfully used in the literature to analyze the optimal timing of an investment under uncertainty (see e.g., Dixit and Pindyck, 1994; Trigeorgis, 1999; Kort et al., 2010; Hori and Osano, 2014). In particular, game theoretical decisions under uncertainty have been analyzed with the help of the real option framework in numerous applications, for example negotiating M&As (Lambrecht, 2004; Hackbarth and Miao, 2012; Lukas and Welling, 2012), formation and dissolution of a joint venture (Lee, 2004; Cvitanić et al., 2011; Martzoukos and Zacharias, 2013), collaboration in a supply chain (Amini and Li, 2011; Jörnsten et al., 2013; Lukas and Welling, 2014), as well as competition on IPO markets (Banerjee et al., 2016) or in an oligopoly (Bayer, 2007; Czarnitzki and Toole, 2013; Kamoto and Okawa, 2014).

From a game-theoretic perspective two strands of literature have emerged on this topic. The first strand deals with the fact that the outcome of the negotiations about a common project is the result of a cooperative decision-making process. Here, the agents jointly maximize their profit in a cooperative game-theoretic manner. Collaboration can increase the effectiveness and thus the competitiveness of the collaborating companies (Lee, 2004; Pawlina, 2010; Cvitanić et al., 2011; Lukas and Welling, 2014). However, it requires common decision making, information and knowledge sharing, and the reduction (ideally, elimination) of opportunistic behavior (Maloni and Benton, 1997). Cooperative game-theoretic modeling requires that all agents involved in the negotiation have perfect information. However, companies often do not want to share their private information, maybe due to confidentiality concerns (Lee and Whang, 2000; van der Rhee et al., 2010). Many supply chains, for example, are dominated by a key company with superior negotiating power that allows to keep their own strategic information private though forcing their suppliers and retailers to disclose their private information (Lejeune and Yakova, 2005). The result is a vertical information asymmetry between the key company and the other companies in the supply chain (Li and Zhang, 2008).

In contrast, the second strand of literature allows the agents to individually maximize their profits in the negotiation, leading to an application of non-cooperative game theory. However, it is well known that the outcome of non-cooperative managed projects is threatened by inefficiency, leading to inferior profit sharing, that is, Pareto-inefficient solutions. (see, e.g., Li, 2008). In particular, investment may be performed inefficiently late (Lambrecht, 2004; Cvitanić et al., 2011; Lukas and Welling, 2012, 2014) as well as inefficiently early (Bayer, 2007; Kamoto and Okawa, 2014).

Building on these findings, the aim of this paper is to design a contract that combines aspects of cooperative and non-cooperative bargaining to overcome the specific problem that, on one hand, economically efficient investment can be achieved only by cooperative bargaining, while on the other hand non-temporal and non-cooperative bargaining assigns all the profit to the first mover, that is, the supply chain dominant firm. We show that such a contract design exists in a dynamic continuous-time setting and that the design has the added advantage of allowing the supply chain dominant firm to keep information private. As a result, our paper also contributes to the literature on principal-agent theory with one-sided incomplete information, i.e. when the principal has private information (see e.g. Myerson (199), Maskin and Tirole (1990, 1992)). In particular, our results fortify the findings of the traditional literature dealing with the informed-principal problem insofar as the principal, i.e. the dominant firm, does not perform worse than in the full-information case when retaining some discretion.

The remainder of the paper is structured as follows. Section 2 sets out the general assumption and model structure. The analytical solutions for the extreme poles of negotiating a contract, that is, either completely non-cooperative or completely cooperative bargaining, are presented in Subsections 2.1 and 2.2 and serve as benchmarks for the later analysis. Subsection 2.3 defines the requirements for an optimal non-cooperative solution and Section 2.4 gives an example of such. Section 3 concludes and offers some suggestions for future research.

## 2. Preliminaries

We consider a (potential) supply chain consisting of the multinational key company $K$ and a local retailer $R$. The key-company produces a good with manufacturing costs of $c_K>0$ per unit and has established a binding retail price of $p_R>c_K$ per unit. In $t_0$ the key company has the opportunity to invest in the expansion of its business into a new foreign market. There, it depends on the cooperation of the local retailer $R$. The expansion requires the key company to make an investment of $I_K>0$. Likewise, the retailer has to make an investment of $I_R>0$.[1]

The (potential) revenues $v(t)$ in the local market evolve stochastically over time due to overall economic uncertainty as well as due to uncertainties regarding customer's attitudes and behavior. In particular, we assume that they follow the geometric-Brownian motion

$$dv(t) = \mu v(t)dt + \sigma v(t)dW(t), \quad v(0) = v_0>0 \tag{1}$$

with $v_0>0$ as the (potential) revenues at time $t_0$, $\sigma\geq 0$ as the volatility of the (potential) revenues, $\mu\mathbb{R}$ as its growth rate, and $dW(t)$ as the increment of a Wiener process with zero mean and variance equal to $\sqrt{dt}$ which is correlated to the market portfolio. The degree of this correlation is assumed to be constant and measured by $\rho\in(-1,1)$. After the expansion in the local market, the key-company's profit at time $t\geq t_0$ equals $\frac{p_K-c_K}{p_R}v(t)$. Here, $p_K\in[c_K,p_R]$ denotes the sales price to the retailer. Likewise, the retailers profit at time $t\geq t_0$ equals $\frac{p_R-p_K-c_R}{p_R}v(t)$ with $c_R\in[0,p_R-p_K-c_K]$ as the retailer's operational costs per unit sold.

[1] For example, the key-company has to bear costs for expanding its production and logistics network, while the retailer has to bear costs for preparing the distribution network.