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Capacity investment decision in co-opetitive network by information sharing ☆

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ABSTRACT

The proposed research concerns the capacity investment decisions in a co-opetitive network. The proposed model takes into account a certain degree of information sharing: specifically, the standard real option methodology is combined with a fuzzy engine. The fuzzy engine collects the information of the network in order to support the capacity investment decision. In particular, the environment concerns the capacity expansion issue for independent plants operating in a co-opetitive network. The proposed approach is compared with a case characterized by no information sharing among the plants. An opportune simulation environment (based on the JAVA package) has been developed in order to test the proposed approach in several environmental conditions. The simulation results highlight the benefits of the proposed approach: the strong reduction of the capacity investment value and a more specific identification regarding the market conditions in which this goal is relevant.

1. Introduction

Market globalization, aggressive economic competition and know-how diffusion drive the enterprises to adopt new business models. The establishment of inter-firm relationship seems to be the best answer to these competitive environments. In this context, inter-firm networks are considered an important model of organization development to enable an entrepreneurial firm to grow and survive (Freel, 2000). In particular, the Small and Medium Enterprises (SMEs) can gain competitive advantages from network business models because of their peculiar characteristics as: reactiveness, proactiveness and agility that allow to establish short-term networked enterprises and business alliances. Several types of inter-firm cooperation have been suggested in literature (see Varamaki & Vesalainen, 2003) as: development circle, loose cooperative circle, project group, joint venture, join unit, and subcontracting. Moreover, the inter-firm relationship can be the key to respond to the economic crisis (Wartzman, 2008). A most promising perspective of inter-firm relationship can be the co-opetition concept: in this business strategy, companies must both co-operate and compete. Brandenburger and Nalebuff (1996) expanded the concept of co-opetition: it is a trade-off between two extreme scenarios. At one hand, we have the competitive scenario, where plants interact based on a fully divergent interest, and on the other hand there is the co-operative situation where plants interact based on a completely convergent interest. Examples of co-opetition regard several sectors (Barretta, 2008; Lambin, 2008; Luo, 2007): automotive companies, healthcare sector and semiconductor companies. One example of real application of co-opetition approach was applied in Italy in 2002. The two biggest motorcycle companies, Aprilia and Piaggio made an alliance for joint-procurement, though competing in the final market. In another field, Supply On is a successful provider of supply and engineering services founded by suppliers competing in the same market (Meder, 2005). An interesting empirical research from Quintana-Garcia and Benavides-Velasco (2004) provides evidence of co-opetition cases in new product development among European small and medium firms in biotechnology industry. Wilhelm and Kohlbacher (2011) examined the case how knowledge co-creation takes place within the Toyota network. They proposed that the duality of competitive and cooperative forces (that is, 'co-opetition') in a business partnership has played a hitherto neglected role in the process of knowledge creation for multi-technology innovations.

The aim of this paper is to investigate the capacity expansion issue for independent plants operating in a co-opetitive network. Two models are proposed: the first one with any information exchange, based on the standard real options approach (used as a benchmark); the second characterized by a certain degree of information sharing: specifically, the real options methodology has been combined with a fuzzy engine. Furthermore, a simulation environment has been developed in order to test the proposed models. The remainder of the paper is structured as follows: Section 2 presents the overview of the literature; Section 3 provides a general description of the co-opetition network, while the capacity investment model is introduced in Section 4. The developed simulation environment and the simulation results are

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respectively presented in Sections 5 and 6. Finally, conclusions and further research paths are withdrawn in Section 7.

2. Literature review

The capacity investment problem involves decisions concerning size, timing, and location of additional capacity. Mieghem (1999) builds a game theoretical model on production outsourcing with respect to investment decisions. The goal is to reduce all decentralization costs and coordinate capacity investment. Kouvelis and Milner (2002) considered two-stage supply chains and the impact of supply/demand uncertainty on capacity analyzing outsourcing decisions. Bhutta, Huq, Frazier, and Mohamed (2003) and Mohamed and Youssef (2004) developed an integrated production planning, distribution, and investment model for a multinational firm that produces products in different countries and distributes them to geographically diverse markets. The results indicated that the exchange rates and initial capacity levels of the plants have significant effects on the production, distribution, and investment decisions, and consequently, on the profit. Plambeck and Taylor (2005) studied a model with two original equipment manufacturers (OEMs) who sell their capacity to the contract manufacturer (CM). In the first stage, the OEMs non-cooperatively choose their capacity and innovation levels. In the second, cooperative stage, the manufacturers pool their capacity and negotiate the allocation of the additional profit stemming from capacity pooling. They showed the impact of the bargaining power of different supply chain members on equilibrium decisions and the resulting profit. Kulkarni (2006) studied optimal capacity acquisition in a basic process plant network considering random yield and random demand. The experiments conducted highlight that traditional risk-pooling behaviour of plant network capacity may not apply when yield is uncertain.

Yilmaza and Çatayb (2006) formulated as a 0–1 mixed integer programming model. The objective of the model proposed is to minimize the costs associated with production, transportation, and inventory as well as capacity expansion costs over a given time horizon.

Julka, Baines, Tjahjonob, Lendermanna, and Vitanov (2007) discussed the state-of-the-art in multi-factor models for capacity expansion of manufacturing plants within a corporation. One of the weaknesses is that the solution strategy adopted by most authors is almost exclusively mathematical. Similarly, none of the works identified the decision makers who need to be involved, or provided guidance about the time and resources required to carry out the analysis. Dulluria and Srinivasa Raghavan (2008) analyzed the problem of the original equipment manufacturer (OEM) that collaborates with tool suppliers for deciding the optimal capacity investment. Bilgina and Azizoğlu (2009) addressed an operation assignment and capacity allocation problem that arises in semiconductor industries and flexible manufacturing systems. They showed that the problem is *NP-hard* in the strong sense; they developed two heuristics and a Tabu Search procedure. The results of their computational tests have revealed that our Tabu Search procedure produces near optimal solutions very quickly.

Kogan, Charles, and Tapiero (2009) have focused on the co-investment problem in a supply chain infrastructure. Several applications and examples were presented and open-loop, as well as feedback solutions were found for non-cooperating plants, long and short-run investment cooperation and non-simultaneous moves (Stackelberg) plants. Ahlert, Corsten, and Gossinger (2009) investigated a production network that uses the capacity of network partners in order to fulfil network orders. The network partners are autonomous enterprises; therefore, an iterative coordination algorithm has been designed aiming at balancing both the objectives of the network level as well as of the corporate level. The central problem of sizing the network capacity pool is solved iteratively by a decentralised planning process applying the top-down/bottom-up principle. Yoon and Nof (2010b) proposed a demand and capacity sharing protocols to find efficient demand and capacity sharing decisions in the collaborative network. Numerical examples indicate that enterprise collaboration by the proposed demand and capacity sharing decisions and protocols can significantly increase the demand fulfillment rate and the total profit of the network. While complete collaboration can increase the demand fulfillment rate, partial collaboration by design is preferred in terms of the total profit of the network under certain conditions. Yoon and Nof (2010a) addressed the problem of affiliation/dissociation decision in a collaborative network related to the performance of the network in terms of capacity and demand sharing.

Moreover, as highlighted by the Harvard Business Review article (December 2004): "*Companies that rely solely on discounted cash flow (DCF) analysis underestimate the value of their projects and may fail to invest enough in uncertain but highly promising opportunities. Far from being a replacement for DCF analysis, real options are an essential complement, and a project's total value should encompass both. DCF captures a base estimate of value; real options take into account the potential for bug gains*".

Among the most recent research, the following concerns the study of capacity investment by real option approach. Sarkar (2009) proposed a model of investment in excess capacity by real option methodology. The approach proposed models the timing and capacity decisions in 'lumpy investment' where the capacity, once installed, cannot be adjusted in the future. Rosqvist (2011) introduced a straightforward way of adopting options theory in the context of real options in capacity management. The analysis is based on a decision cycle which is temporally divided into two market periods. The first period concerns the current market situation, thus optimizing the production capacity according to current demand. The second period represents an uncertain production environment for which real options can be planned, based on demand and supply forecasts. Yuan (2009) presented a model of optimization under uncertainty combining system simulation with GA-based optimization to resolve the expansion problem. The options are evaluated by real options methodology and the simulation by Monte Carlo approach. The model concerns only one industry.

Therefore, in the authors' view, the acceptance of the real options tool, particularly for capacity investment decision, integrated with the network theory could be really interesting because of the combined importance of uncertainty and managerial decisions. The main contribution of this paper is the analysis of capacity investment decision in a network of enterprises that collaborate in a co-opetitive context. In particular, it is investigated how the information shared among partners belonging to the same network can improve the capacity investment decision. The innovative aspect of the proposed approach consists on the information used as support for the decision making process. The coordination methodology among the partners of the network provides the information, while the fuzzy tool is developed to collect these information and support the capacity investment decision. A simulation environment is developed to test this integration and to evaluate the benefits of the real options methodology combined with a fuzzy engine.

3. Co-opetitive network

The co-opetitive network consists of a set of independent plants that collaborate to share production capacity. Each plant works in a