WILLINGNESS TO COOPERATE IN THE SUPPLY CHAIN A PRELIMINARY AGENT-BASED MODELING APPROACH

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INTRODUCTION

In the recent agri-food business, vertical coordination has become relevant in order to guarantee the consumer the correctness of credence attributes. To fulfill such requirements, more strictly coordinated supply chains have been evolved. Quite often such chains are formed of independent but collaborating enterprises called supply chain networks. According to Lazzarini et al. (2001) and Omta et al. (2001), „supply chain networks are commonly characterized as firms that are embedded within a complex network of horizontal (i.e. strategic alliances, joint ventures) and vertical (buyer and supplier) relationships" (Ng et al., 2003). Such as supply chain network also could be defined as a strategic network (Hanf et al., 2004). According to Burr (1999), intensity of the relations in strategic network is high and set for a long term. Traditionally, the management of such supply chains focused on operational aspects, but there is a benefit in considering retail supply chain strategy in terms of relationship building among retailers and their key supply chain members (Mentzer et al., 2000). Mentzer et al. (1999) defined supply chain management as "the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain (that consists of multiple firms), for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole". This suggests supply chain management is the management of close interfirm relationships, so understanding interfirm relationships is important for successful development in a supply chain network (Mentzer et al., 2000).

In this context, the question arises whether firms are able to be integrated in such a vertical coordinated agri- food business. Supposedly, forming cooperation i.e. cooperatives might be a feasible way. Ring and Van de Ven (1994) made the definition of cooperation as a dynamic process by including the willingness of individuals to continue in cooperative relationships. Such process of developing cooperation is central to managing inter-organizational relationships. Managers need to know more than the input conditions, investments, and types of governance structures required for a relationship. Furthermore, Ring and Van de Ven (1994) focused on the question "how do cooperative inter-organizational relationships emerge, grow, and dissolve over time?"

Thus, the management of actors in cooperation is a very complex and dynamic environment. Therefore, agent-based modeling and simulation (ABMS) might provide a new possible approach to model systems comprised of interacting autonomous agents because in such model agents might have certain characteristics as Macal and North (2006) indicated as follows. Agents are identifiable, situated in an environment, have the ability to recognize and distinguish the traits of other agents, goal-directed, autonomous and self-directed, flexible, having the ability to learn and adapt its behaviors based on experience. In this paper we propose to initiate a research on an agent oriented supply chain in which partners are able to create cooperation. The aim of the paper is to introduce ideas regarding the ABMS implementation and to build a model which captures the change of willingness to cooperate within a first simplified supply chain model of an agricultural market.

THEORETHICAL BACKGROUND

Supply chain networks

In this paper one particular network is in focus: a broker-coordinated strategic network in a hierarchical-pyramidal style. The term strategic network is also referred to as "supply chain networks" (SCN) or "netchains". According to Lazzarini et al., (2001) and Omta et al., (2001) supply chain networks are commonly characterized as firms that are embedded within a complex network of horizontal (i.e. strategic alliances, joint ventures) and vertical (buyer and supplier) relationships' (Ng et al., 2003), and the relations within such a network are generally considered long term and intense. In these conditions, a strategy leading focal company (often a manufacturer or retailer) builds the core element of the network. The objective of this structure is to produce higher quality and/or higher efficiency by co-operation rather than by full integration of the supply chain or by market transactions (Hanf and Kühl, 2002). Because of the long lasting explicit or implicit contracts the other network actors are heavily dependent on the focal company but, the level of dependency is higher for vertical than for horizontal ties (Wildemann, 1997). Formal and informal mechanisms that align the different interests can be used to overcome these problems. Formal mechanisms are: contracting (Williamson, 1999), common ownership of assets (Grossman and Hart, 1986), monitoring and sanctions (Williamson, 1985), and the prospect of future interactions (Baker et al., 2002). Informal mechanisms to align interests are identification and embeddedness (Granovetter, 1985; Gulati, 1995; Kogut and Zander, 1996). Enhanced communication enables learning of and reacting to changes in one's partners' expectations; therefore, it can be regarded as another informal mechanism, i.e., ineffective communication causes conflicts resulting in improperly functioning relationships (Mohr and Nevin, 1990). Overall, trust can be seen as a prerequisite to gain the advantages of cooperation, because trust reduces the perception of risk associated with opportunistic behaviour, encourages effective communication and information sharing, and creates strong social bonds (Bleeke and Ernst, 1993, Mohr et al., 1996).

To create a successful collaboration among network actors, appropriate management must be built on network, dyadic and firm level, which adopts both the mechanisms of aligning interests as well as aligning actions. These must be simultaneously achieved (Hanf and Dautzenberg, 2006). The tools for solving problems in alignment of interest are incentives, sanctions, monitoring, rewards, and punishments but are not sufficient to achieve coordination (Gulati and Singh, 1998). Problems of alignment of actions arise due to the cognitive limitations of individuals that deny them comprehensive knowledge of how others will behave in situations of

interdependence, and how they are interdependent with others. In the context of alignment of actions, the complexity of network structures plays an important role. The more actors are involved in a network the higher is the number of interactions as well as the number of interdependencies. Since the increase of interdependencies is disproportional, the coordination task is extremely difficult. However, if actors are not aware that their actions are interdependent different problems arise. Because cooperation involves two (or more) independent enterprises, its key problem is that each firm has different motives, reasons and preconditions for joining the collaboration which might lead to opportunistic behavior. Self-interested individuals optimize their own private benefits before they strive for collectively-beneficial outcomes and it can be regarded the question of motivation: which incentives can be used? In analyzing these challenges, two managerial imperatives are suggested — the need to control and the need to cooperate (Das and Teng, 2000; de Rond and Bouchikhi, 2004). The first, control emphasized in the transaction cost framework, is the need to minimize the likelihood of partner's opportunistic behavior (Williamson, 1985) and the bargaining costs in an ongoing relationship (Milgrom and Roberts, 1992; Pearce, 1997). The second is the need to cooperate with a partner to achieve joint or individual aims which is not costless. Successful collaboration requires that the partners be able to communicate, establish and maintain an inter-organizational interface (White and Siu-Yun Lui, 2005).

Willingness to Cooperate

Cooperation can be defined as a process by which individuals, groups, and organizations come together, interact, and form different relationships for mutual gain or benefit (Smith et al., 1995). The process of developing cooperation is central to managing inter-organizational relationships. Managers need to know more than the input conditions, investments, and types of governance structures required for a relationship. These process issues have important sequential implications for routine. The ways in which firms negotiate, perform, and adjust the forms of an inter-organizational relationships influence the degree to which parties judge it to be equitable and efficient (Guthet al., 1982) as well as influence motivations to continue in, or stop the relationship over time (Friedman, 1991). Interaction processes among cooperating firms may spread a positive, neutral, or negative overtone to the relationship, influencing the degree to which parties settle disputes arising out of the inter-organizational relationships (Loewenstein et al., 1989; Schmitt and Marwell, 1972; Ring and Van de Ven, 1994). In general, problems in cooperation arise because self-interested individuals optimise their own private benefits before they strive for collectively-beneficial outcomes (Gulati et al., 2005). Many authors have addressed this problem by using game theory, particularly focusing on the prisoner's dilemma and its varieties, such as the tragedy of the commons (Selten and Harsanyi, 1972). Gulati et al. (2005) conclude that the problem of cooperation can be regarded as one of motivation i.e., which incentives can be used. Since such cooperation consists two or more actors, who must consider that each firm has different motives, reasons and preconditions for joining, firms usually are not equable; cooperation might be discouraged (Hanf and Dautzenberg, 2006). Such heterogeneity could cause a number of inefficiency problems like; agency problems, commitment problems, decision-making problems, opportunistic behavior, coordination problems, and strategy-related problems (Hanf and Schweickert, 2007). Furthermore, other factors might be an obstruction of fluent cooperation action. For example, cooperation does not always create short-term advantages for the firms involved, but they also absorb resources – especially during their establishment, because it is beneficial in the long-term.

Benefits of cooperation

Firms have to recognize cooperation as a mean to overcome limitations of their resources based on their calculations. Firms also have to understand that cooperation is a lever that increases their profits. Overall, firms must understand cooperation as a unique source for pursuing strategic objectives by achieving cooperation benefits (Echols and Tsai, 2005; White and Siu-Yun Lui, 2005; Zaheer and Bell, 2005; Hanf and Dautzenberg, 2006).

For example in modern supply chain networks firms can reduce the need for costly direct monitoring, lower resource demands than full ownership - because individual firms do not have to supply all resources (Combs and Ketchen, 1999) by having access to complementary assets (Rothaermel, 2001). Interfirm cooperation can be useful way to have alternative ways of reducing transaction costs (Shaw et al., 2000). It can help to overcome long-term contract's constraints to have important safeguard mechanism mitigating external and internal hazards and to encourage long-term evolutions (Luo, 2002). Firms in cooperation can easier build a brand name, design products (Heide and Miner, 1992; Combs and Ketchen, 1999) reveal information (Ross and Conlon, 2000) for example new technology from partners and to develop new product (Rothaermel, 2001), gaining complementary skills by getting into sources of know-how located outside the boundaries of the firm (Ring and Van De Ven, 1992). Furthermore, firms have better chance to comply with external pressure (Hanf and Dautzenberg, 2006). This is particularly true in the context of the agri-food business since the "new food quality" is being produced as the result of the cooperation between all stages of the food chain (Hanf and Hanf, 2007; Theuvsen, 2004; Obersojer and Weindlmaier, 2006; Menard and Klein, 2004).

MOTIVATION FOR USING AGENT-BASED MODELING

Agent-based modeling (ABM) is a modelling concept in which each "agent" in a system corresponds to an autonomous individual in a simulated area. The idea is to construct the agents and their attributes and to link them through a set of dynamically interacting communication and behavioral rules to create complexity like that which we see in the real world. The process is one of emergence from the lower (micro) level of the system to the higher level (macro) (Epstein and Axtell, 1996, Li and Sim, 2006). ABM is a deterministic rules-based approach and allows the modeling of the finer detail of the structure of each component's operation, the signals they pick up and the rules they use to process those signals when making a decision. (Bryceson and Smith, 2008)

Intelligent distributed systems, e.g. multiagent systems, enable increased autonomy of each member in the supply chain. Each partner (or production subsystem) pursues in- dividual goals while satisfying both local and external constraints (Maturana et al., 1999). Therefore, one or several agents can be used to represent each partner in the supply chain (plant, workshop, etc.). Moreover, the agent paradigm is a natural metaphor for network organizations, since companies prefer maximizing their own profit than the profit of the supply chain (Viswanathan and Piplani, 2001). (Moyaux et al., 2006)

In fact, the distributed manufacturing units have the same characteristics as agents (Cloutier et al. 2001) (based on Wooldridge's and Jennings's (1995) definition of agents, (Moyaux et al., 2006)): – autonomy: a company carries out tasks by itself without external intervention and has some kind of control over its action and internal state; – social ability: a company in the supply chain interacts with other companies, e.g. by placing orders for products or services; – reactivity: a

company perceives its environment, i.e., the market and the other companies, and responds in a timely fashion to changes that occur in it. In particular, each firm modifies its behaviour to adapt to market and competition evolutions; – pro-activeness: a company not only simply acts in response to its environment, it can also initiate new activities, e.g. launching new products on the market.

Main disadvantages of multiagent systems (Moyaux et al., 2006)

- theoretical optima cannot be guaranteed, because there is no global view of the system;
- predictions for autonomous agents can usually be made only at the aggregate level;
- in principle, systems of autonomous agents can become computationally unstable, since, according to System Dynamics, any system is potentially unstable.

Main advantages of multiagent systems (Moyaux et al., 2006)

- because each agent is close to the point of contact with the real world, the systems's computational state tracks the state of the world very closely
- no need for a centralized database
- because overall system behaviour emerges from local decisions, the system readjusts itself automatically to environmental noise
- the software for each agent is much shorter and simpler than would be required for a centralized approach, and as a result is easier to write, debug and maintain.
- because the system schedules itself as it runs, there is no separate scheduling phase of operation, and thus no need to wait for the scheduler to complete.

Related works

Arguments in support of using multi-agent systems in supply chain management can be found in the literature. Researchers have already used agent technology in industry to concurrent engineering, collaborative engineering design, manufacturing enterprise integration, supply chain management, manufacturing planning, scheduling and control, material handling, and holonic manufacturing systems (Shen et al., 2001). Concerning supply chains, Dodd and Kumara (2001) think that Fox et al. (1993) were probably the first to organize the supply chain as a network of intelligent agents. Indeed, supply chains are made up of heterogeneous production subsystems gathered in vast dynamic and virtual coalitions. Supply chains have long been regarded as complicated systems (Swaminithan et al., 1998)) involving both strategic and operational issues along with complex social and functional behaviours. In agri-food sector, Bryceson and Smith (2008) outlined a pilot investigation looking at a number of approaches to conceptualising and modelling an agri-food chain and its related decision making processes to better evaluate the impact and effects of that decision making and associated information flows across the components of the agri-food chains. Cooperative behaviors occupy a critically important place in the research into individual as well as both group and societal behavior. For example, Peter Danielson's contribution, Competition Among Cooperators: Altruism and Reciprocity (2001), builds on critical earlier contributions by Axelrod (1984), (Elliott and Kiel, 2002); furthermore Hendrikse also applied ABM in topic of 'Corporate Governance, Diversification, and Performance' (Hendrikse, 2008).

A SIMPLIFIED AGENT-BASED-MODEL

Supply chains can be characterized by vertical and horizontal cooperation of economic agents. Whether and how the agents will collaborate or not, depends not only on the attributes of the agent and the environment but also on the nature of the interdependencies of the system. An appropriate tool to investigate the features and dynamics of this kind of complex systems is Agent based modeling (ABM). We used this approach in a first step to model vertical interactions of farmers producing an agricultural input.

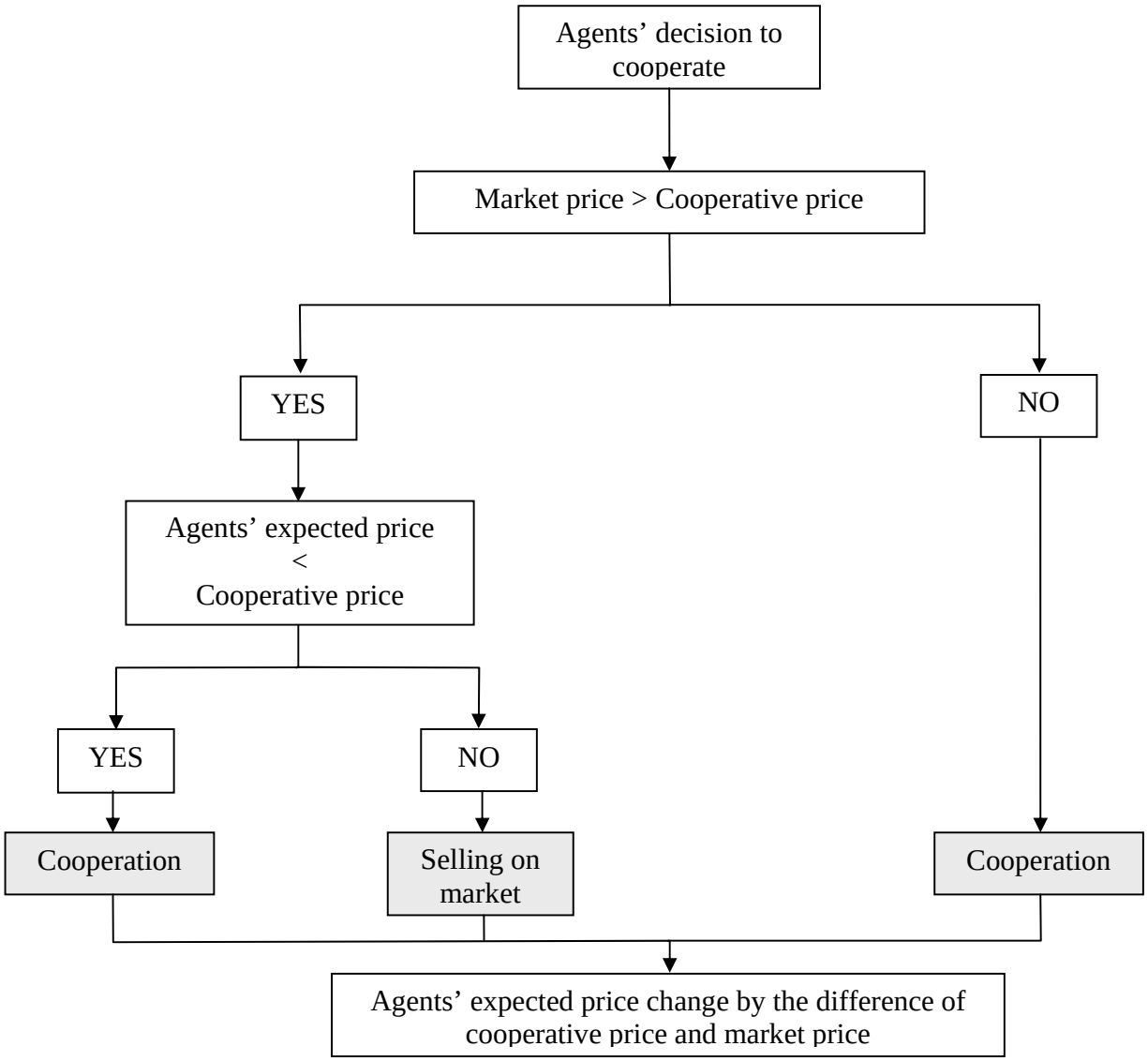

Figure 1: Decision Process of the Agents

There are three different agents. Cooperative, Market and Farmer. Initially, the maximum product price and the rate of cooperative price in maximum product price are defined. Crucial variable is the farmer's expected price and market price are randomly assigned up to the maximum price (the latter is randomly defined in every period). The all of the price variables are individual attributes of the agents. An interesting question is whether farmer will collaborate in a production cooperative or prefer to sell the input to open market. We base the decision regarding cooperative behavior (joining the cooperative) and non-cooperative behavior (selling to open market) of the agent on three. We assume that the farmer passes a two stage decision process starting with a certain expected price (initially assigned by random). Figure 1. highlights the structure of the process. In the first stage farmer decide to cooperate or not according to the prices of cooperative and market. Since market price is not predictable in the future, farmer has to consider the previous price comparing with the cooperative price. The cooperative price is offered in advance. Which means that farmer knows it is a predictable, sure price. If the price of the cooperative is higher than the market price was in the past, farmer sells to cooperative. If the price of market was higher than cooperative offer, farmer goes to the second stage of the decision. In the second stage of decision, farmer considers the price according to its expected price. It means that if the expected price is higher than the cooperative price, farmer takes the risk and sells on the market. If the expected price is lower than the cooperative price, farmer enters to the cooperative. Finally, in all cases the farmer`s expectation level changes in every period by the difference of the market price and cooperative price. It means that if farmer sells to cooperative and on the market there is better price it follows that farmer's expectation will grow and it will become higher than the cooperative price and farmer will quit from cooperative.

DISCUSSION

In the recent agri-food business, vertical coordination has become relevant in order to guarantee to the consumer the correctness of credence attributes. To fulfill such requirements, more strictly coordinated supply chains have been evolved. This suggests the building and management of close interfirm relationships, so understanding interfirm relationships is important for successful development in a supply chain network (Mentzer et al., 2000). In managing inter-organizational relationships, the process of developing cooperation is central, therefore managers need to know more than the input conditions, investments, and types of governance structures required for a relationship. We use agent based-modeling method thanks to its adaptability, autonomy and social ability, it is a viable technology for the implementation of communication and decision-making in real-time. Each agent would represent a part of the decision-making process, hence creating a tight network of decision makers, who react in real-time to customer requirements, in opposition to the flood of current processes, which is decided before customers place an order (Moyaux et al., 2006).

This paper introduces the first initial stage of the model. Based on a theoretical background we simulated a small vertical cooperation an agent based modeling approach. The agents' decision is based on prices (market price, cooperative price, expected price) experience. We implemented this decision process as a dynamic two stage system. Even though, the model is still simple and predictable we can draw (and support) important conclusion. Cooperation can be a mean to reduce risk. For instance, producers may benefit from contracting in order to reduce market price risk, while processors can assure quantity and quality of the input. The organization and system dynamics of vertical cooperation in supply chains will be a major question for our further research.

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