SME E-Cooperation:
A Theoretical Team Contract Analysis Under Hidden Information

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ABSTRACT

Virtual Cooperation among SME firms can be analyzed from different theoretical perspectives. This paper considers e-cooperation among firms under asymmetric information. Firms cooperate jointly to produce some output or service, and they organize in teams whose firms' characteristics are imperfectly observed. Suppose firms can observe their efforts or actions but they cannot observe the disutility of effort which they can discover after the contract is signed. The objective of this paper is to analyze virtual cooperation contracts under hidden information based on the original papers of Holmstrom (1982) and Rasmussen (1987). Some conditions are derived under which it is possible to implement an optimal sharing rule for a virtual team of SME under a hidden information frame.

Keywords: *Asymmetric Information, Business Management, Contract Theory, Networks, Teams, Virtual Cooperation*

1. INTRODUCTION

Globalization and the increasing complexity of production processes have altered traditional operations' management, leading to a new challenge for small and medium sized enterprises (SME). Inter-firm cooperation has emerged in response. Cooperation plays an important role in the survival of many small and medium sized businesses (Fuller-Love & Thomas, 2004; Rauch, 2001, Kosacoff & López, 2000; Oughton & Whittam, 1997).

Nowadays, since the evolution of network technologies and the decrease in transaction costs due to new Information and Communication Technologies (ICT), technology providers have developed innovative solutions for SME as regards communication and the management of business. The *New Economy* offers new opportunities for small businesses in terms of internationalization, access to external markets (Chong, 2008; Alderete, 2007) and achievement of further business goals (Aral et al., 2006). Besides, SME in local networks can accomplish a different way of doing business, where the advantages of the local embeddedness, such as informal exchanges, could be offset by the benefits of electronic marketplaces.

The adoption of common standards, exchange of information and shared use of common facilities are all examples of cooperation in which firms may increase their profits. Traditional theory pays little or no attention to

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the role of information, which evidently lies at the heart of organizations (Holmstrom, 1982).

The intensive application of the new information and communication technologies seeks to enhance the competitiveness of the partners of a specific network. However, SME do not just face advantages but also challenges. Awareness, confidence and competence in e-business play a significant role vis-à-vis e-business platform adoption (Braun, 2003). SME can display different abilities towards adoption of networked technologies; for instance, some firms may lack technology skills. Besides, the virtual enterprise requires flexibility and agility, which can be discovered once working in the team. Some authors (Cragg et al., 2002) express the concept of IT alignment which means 'fit', it expresses the idea that the object of design, e.g., an organisation's structure or its information systems must match its context in order to be effective (Iivari, 1992).

The concept of a "team" is described as a small number of individuals with complementary skills, who are equally committed to a common purpose, goals, and a working approach for which they hold themselves mutually accountable. It is worth mentioning that virtual teams are often formed to overcome geographical or temporal separations (Cascio & Shurygailo, 2003). Virtual teams work across boundaries of time and space by utilizing modern computer-driven technologies. The term "virtual team" is used to cover a wide range of activities and forms of technology-supported working.

Organizations are shedding conventional work team structures in favor of virtual team structures that are increasing in popularity (Lee-Kelley, Crossman, & Cannings, 2004).

Pinsonneault and Caya (2005) review the extant empirical literature on virtual teams and present what we know and what we do not know about them. By stressing the variables affecting virtual teams, they assess the effects of virtual teamwork on group processes and outcomes.

E-collaboration enables collaboration between individuals not constrained by geographical distance or time. The emergence of the virtual team concept provides organizations with an alternative approach to manage work and individuals that are geographically separated (Gatlin-Watts, Carson, Horton, Maxwell, & Marltby, 2007).

In this paper, we consider a team to be a loose-knit group of firms who are organized so that their productive inputs are combined to offer a common output or service by means of an ICT management. In a team, each member firm contributes to some part of the production. A special case of team is the virtual enterprise, an arrangement of the best core competencies of independent companies which cooperate with each other. They are connected by the new information and telecommunication technologies during a certain period of time. Therefore, it is a main goal of the team to link its members to their core competencies. In other words, a certain level of competitiveness may be a prerequisite for a SME's survival when dealing with dynamic conditions in the business environment (Ebrahim et al., 2010). Increasing use of virtual teams has highlighted the need for organizations to focus on ways to improve their performance (Chieh Liu & Burn, 2009).

Cases of virtual teams involving SME arise progressively. Neto (2007) analyzes the case of the IMMPAC (Integration and Modernization of Personal Computers and Small Companies to Reach the Competitiveness) project. This study involves a wide mapping of industrial clusters all over Mexico, of favorable areas for developing agglomerations of SME (clusters) and a university in order to create a cooperative net. After the accomplishment of such mapping, which identified activities and favorable areas for forming clusters (Federal District -Automotive and Textile; Jalisco: Food and Furniture Industries), a field research was conducted in those areas. Through a statistical sample, the different characteristics of the companies (percentile increase in productivity, employee turn-over rate, age of equipment, level of use of information systems, lead time, etc.) were compared with the international patterns, identifying items that would deserve more attention to obtain improvements. The IMMPAC project thus created a methodology to support the companies. This project involves the following points: diagnosis and evaluation of the company, through productivity indicators (education level and employee's training, quality control, accomplished preventive maintenance), identification of the central products and core competencies, taking into account the technological and human resources besides the processes employed by the company's strategic and technological integration planning.

Another example of a team is the vertical export consortium of dental equipment or automotive production. Components' production depends on each member firm while final assembly of the components for final output could be contingent on a trademark owned by the team. Components & Machinery by Brasil export consortium was built in 2003 as a result of a group made up of the largest and best Brazilian producers of leather, machines and components in the footwear industry. Member firms are not competitors, produce complementary components (specified by contract) and expect to form a shoe industry supply chain. Firms must accomplish some requirements to be a member, for instance in product quality. APEX (Brazilian Agency of Export Promotion) acts as a broker and promotes the consortium's image through the trademark By Brasil. By its intermediation, an increase in technological innovations (including ICT) is achieved (Barbieri et al., 2007).

Members of a SME team may be seen as providing two kinds of services: they supply inputs for production and process information for decision making. Along with this dichotomy goes taxonomy for incentive problems. While moral hazard refers to the problem of inducing agents to supply proper amounts of productive inputs when their actions cannot be observed and contracted for directly, hidden information models refers to a situation where actions can be observed but what is not observable after the contract is signed is the random realization of the firm's disutility from effort, which he privately observes after the contract is signed. SME will likely have varying levels of digital literacy and lack understanding of the potential strength of interactive communication across business and customer strata, and clustering benefits.

Glückler and Schrott (2007) argue that strategically, managers of virtual knowledge networks should focus their attention not only on the qualifications of individuals (that explain disutility of effort), but also on communication structures within their work groups. Remidez et al. (2010) and De Luca et al. (2006) show that a virtual team whose participants used certain e-collaboration technologies, such as a template-driven messaging system perceived better quality (team members had a higher level of ability) and achieved success in the team outcome.

Thus, a relatively smaller effort is followed by a large cost of effort due to low ability to manage telecommunication networks. A SME member of a team incurs production and transaction costs which are privately known after the membership contract is signed. To compensate for these costs, each member firm is offered a share of the team output. The team manager or principal must design a mechanism to reimburse the agent for his efforts, but is constrained by the information about technology skills. As the principal cannot observe the state of the system, she may pay the agent contingent on the observable action. Under many sharing rules, a member could be better off lying about its costs which could lead to a non optimal output and affect the team's efficiency.

Based on team contract literature (Holmstrom, 1982; Rasmusen, 1987; Eswaran & Kotwal, 1984; McAfee & McMillan, 1981) multi-agent organization characteristics are:

- Joint production or outcome: from which the free riding problem derives.
- Competition among agents: to control incentives. It allows information acquisition from agents.

According to team theory, the free riding problem is not just a matter of uncertainty but the result of searching for budget balancing (a budget balancing constraint means the sum of shares equals 1). Holmstrom (1982) says that in a context of moral hazard with risk neutral individuals, the optimal allocation cannot be implemented under a budget balancing rule, since firms will always prefer to shirk as the cost of such behavior is shared among all members while the benefits are conferred solely upon the individual firm. According to Rasmusen (1987), by allowing a degree of aversion from its member, the team will ensure that output is fully and unconditionally shared among its members. Under uncertainty, incentives will be effective if the number of agents converges to infinite and agents are risk adverse. Hence, contracts with budget balancing do incentivize the optimal effort level. Therefore, moral hazard can be solved in the absence of a principal or where the principal takes a different role.

Groups continue to be important factors in organizational decision making and problem solving. Profit sharing, stock option and stock ownership plans that cover all members can also be somewhat supportive of problem-solving groups. They distribute financial rewards that may be somewhat related to the effectiveness of the problem solving groups and the implementation of their ideas (Gibson & Cohen, 2003).

The problem is to motivate firms to take an appropriate observable action (his report) on the basis of hidden information. The strategy made by the member firms, that is the function from his information to his choice or effort, is unobserved and therefore, could be seen as a special case of hidden action models (Milgrom, 1987). It is through these costs and shares that consideration of incentive compatibility is introduced to the team output problem which has been considered in moral hazard frames. Our goal is to maximize team efficiency by distributing shares among the members.

2. THE MODEL

Consider the following simple model of virtual team production. There are n firms member of a team, indexed i. The firms' level of effort, called e, is fully observable (for instance, production of a specific component for the team product). We suppose that the level of effort e can be measured by a one-dimensional variable $e \in (0,\infty)$. Since effort is observable, we could think that compensation (share) is a direct function of ei. However, states of nature affect the level of disutility from effort θ, while the levels of effort are observable. In this case, team output depends not only on effort levels but also on disutilities of effort.

The presence of states of nature means that what is not observable after the contract is signed is the random realization of the firm's disutility from effort. There are different states of nature:

$$\theta_{-j} = (\theta_1, \ldots\ldots, \theta_{j-1}; \theta_{j+1}; \ldots; \theta_n);\ \theta = (\theta_i, \theta_{-i}).$$

For simplicity, we suppose two different states of nature. For example, a firm can become aware of having networking skills and high competitiveness that turn a high effort into a relative low disutility of effort. Disutility of effort in this frame refers to awareness and technology skills and knowledge of electronic markets, or what some authors called IT alignment. We suppose that the competitiveness level, θi, can take two possible values: θ_l are the less competitive firms and θ_h are the most competitive ones. Prob (θ_h) = $\lambda \in (0,1)$.

The firms' efforts determine a joint monetary outcome $x : e, \theta \to \Re$ which must be allocated among the firms. The sharing rule specifies $s_i(x)$ as firm i's share if the team output is x. Let $s_i(x)$ stand for firm i's share of the outcome x.

The firm is an expected utility maximizer whose Bernoulli utility function over shares and effort, $u(s,e,\theta)$ depends on a state of nature θ that can be discovered after the contract is signed and that only the firm can observe.

We assume that $\theta \in R$, and we focus on a special form of $u(s,e,\theta)$ that is widely used in the literature.

$$u(s,e,\theta) = v(s - g(e,\theta))$$

We introduce the share of the outcome to the function. Hence, utility takes the form:

$u_i(s_i, e_i, \theta_i) = v(s_i(x) - g(e_i, \theta_i))$

Then, each member firm produces an observable effort (component production) with a private cost $g(e,\theta)$ that measures the disutility of effort in monetary units, where the following properties are verified:

$g_e(e,\theta) > 0$ if e>0,
= 0 if e=0.
$g_{ee}(e,\theta) > 0 \ \forall e$
$g_\theta(e,\theta) < 0 \ \forall e$
$g_{e\theta}(e,\theta) < 0 \ if \ e > 0$
$= 0 \ if \ e = 0$

Thus, the firm is averse to increases in effort and this aversion is larger the greater the current level of effort. We also assume that the firm is risk averse, with v''(.)<0.

$u_i(s_i, e_i, \theta_i) = -e^{-\delta_i(s_i(x(e,\theta)) - g(e_i,\theta_i))}$

where δi is the risk adverse parameter and $s_i(x(e,\theta))$ represents the firm i's share of the team output $x(e,\theta)$.

Team Output Under Uncertainty or Non Observability of Disutilities of Efforts

The team output form $x(e,\theta)$ is based on Chambers and Quiggin's state contingent approach of production under uncertainty. The idea is that production under uncertainty can be represented by differentiating outputs according to the state of nature in which they are realized.

Chambers and Quiggin (2002) claim that 'the state-contingent approach provides the best way to think about all problems in the economics of uncertainty, including problems of consumer choice, the theory of the firm and principal–agent relationships'.

The crucial insight of Arrow and Debreu (1954) was that, if uncertainty is represented by a set of possible states of nature, and uncertain outputs by vectors of state contingent commodities, production under uncertainty can be represented as a multi-output technology, formally identical to a non-stochastic technology. Hence, the necessary and sufficient conditions for the existence and optimality of equilibrium are not affected by the introduction of uncertainty.

In the general state-contingent model, there are *M* distinct outputs, *N* distinct inputs, and *S* possible states of nature. In this model, there are 2 distinct outputs and 2 distinct actions or efforts corresponding to the member firms and 2 possible state of nature (disutilities from effort or level of competitiveness).

In the general state contingent model, inputs are committed ex ante and fixed ex post, state contingent outputs are chosen ex ante but produced ex post. The formal structure may be considered as a two period game with nature, with periods 0 and 1. In period 0, the team commits inputs e. When nature reveals the state θh, the firm produces the effort eh. The technology of production determines the feasible strategies (e, x).

According to this approach, the firms' efforts are the production technology inputs that depend on the states of nature, which are uncertain. The following sets characterize the contingent approach:

States of nature $\{\theta_h, \theta_l\} = \Theta$.
Inputs: Efforts $\{e_h, e_l\} = \mathrm{E}$ (committed prior to the resolution of the uncertainty).

State contingent Outputs $\{x_h, x_l\} = X$ where be a strictly increasing sequence of real numbers converging to x.

So, if state $\theta_h \in \Theta$ is realized and the firm has chosen the ex ante effort-output combination (e, x), then the realized output is x_h corresponding to the first element of X.

The technology may be represented by a continuous input correspondence, $e : \Re^X \rightarrow \Re^{\mathrm{E}}$ which maps state contingent ouputs into input sets that are capable of producing that state contingent vector. Formally, it is defined by

$$e(X) = \{e \in \Re^{\mathrm{E}} : e \, can \ produce \ x \}$$

Quiggin and Chambers (2002) impose some conditions on the set e(X).

The most common approach to specifying a stochastic technology is to suppose that production depends upon a vector of inputs (efforts or actions) directly controlled by the firms and a random variable that is beyond the control of the firms. Then, the stochastic production function specifications require that stochastic output be related to inputs by the production function.

The technology may be represented by the constraints

$$x \leq f(e, \theta_i), i \in \Theta$$

Uncertainty is represented by a set of possible states of nature Θ. The state contingent input correspondence associated with it is:

$$e(x) = \{e : x \leq f(e, \theta_i), i \in \Theta\}$$
$$e(x) = \bigcap_{i \in \Theta} \{e : x_i \leq f(e, \theta_i)\} = \bigcap_{i \in \Theta} \bar{e}\{x_i, \theta_i\}$$

Where $\bar{e}\{x, \theta\}$ may be interpreted as the ex post input set associated with the production function for a given realization of the state of nature.

When there are two states of nature, we can think that in a team production there is no substitutability between state contingent outputs. Hence, the technology associated with the stochastic production function may also be referred to as Leontief in outputs. The efforts made by the two member firms are complementary to joint outcome.

If we cannot accept the assumption that the firm has a stochastic production function technology with a single scalar input (effort), the fixed-output proportions property of this technology means that, if the principal can control output in one state of nature (say, the worst), that principal can control the agent's effort, and therefore the output in all states of nature. A necessary condition for differentiability of production function is that the number of inputs should be at least as great as the number of states (Quiggin & Chambers, 2006). This means that if we suppose there are two states of nature we must consider a team production of at least 2 firms.

$$e(X) = \{e \in \Re^{\mathrm{E}} : e\, can\ produce\ x \in \Re^{X*\Theta}\}$$

Inversely, $x(e) = \{x \in \Re^{X*\Theta} : e \in e(x)\}$

3. THE HOLMSTROM MODEL WITH HIDDEN INFORMATION

Following Holmstrom (1982), firms' efforts determine a joint monetary outcome $x : e, \theta \rightarrow \Re$ which must be allocated among the firms.

The question is whether there is a way of fully allocating the joint outcome x so that the resulting noncooperative game among the agents has a pareto optimal Nash Equilibrium. That is, we ask whether there exist sharing rules si(x)>=0, i=1,2 such that we have budget balancing:

1) $\sum_i s_i(x) = X$ and the non cooperative game with payoffs
2) $u_i(s_i(x(e_i, \theta_i)) - g(e_i, \theta_i))$ has a Nash equilibrium e* which satisfies the condition for pareto optimality,
3) $e^* = \arg\max$ $[\sum_i \ln\,(s_i(x(e_i, \theta_i)) - g(e_i, \theta_i))]$

If the sharing rules are differentiable, we find since e* is a Nash Equilibrium that

4) $(s_i' x_i' - g_i') / (s_i(x) - g_i) = 0$, Where $x_i' = \partial x / \partial e_i$

Pareto optimality implies that

5) $x_i' = g_i'$

From 4 and 5 we deduce $s_i' = 1$. But this is in conflict with 1) since differentiating 1 we obtain $\sum_i s_i'(x) = 1$

Theorem 1

There do not exist sharing rules si(x) which satisfy 1) and which yield e* as a Nash Equilibrium in the non cooperative game with payoffs 2).

Proof

Suppose e* is a Nash Equilibrium,

$$e^* = (e_i^*, e_{-i}^*)$$
$$\theta = (\theta_i, \theta_{-i}) \text{ and}$$
$$g_i(e_i, \theta_i) = e_i^2 / \theta_i .$$

Therefore, e* is a Nash Eq. if

$$\ln(s_i(x(e_i, e_{-i}^*, \theta_i, \theta_{-i})) - e_i^2 / \theta_i) \leq \ln(s_i(x(e^*, \theta)) - e_i^{*2} / \theta_i) A \quad (1)$$

Since In is an increasing function of the argument:

$$s_i(x(e_i, e_{-i}^*, \theta)) - e_i^2 / \theta_i) \leq s_i(x(e^*, \theta)) - e_i^{*2} / \theta_i)$$

OP means $x_i' = g_i'$, hence

$$e_i^{*2} / \theta_i - e_i^2 / \theta_i = x(e^*, \theta)) - x(e_i', e_{-i}^*, \theta)) + 0(e_i' - e_i^*)$$

Thus,

$$x(e^*, \theta)) - x(e_i', e_{-i}^*, \theta)) + 0(e_i' - e_i^*) \leq s_i(x(e^*, \theta)) - s_i(x(e^*, \theta))$$

Let {α'} be a strictly increasing sequence of real numbers converging to x(e*,θ). Let {ei'} be the corresponding n sequences satisfying

$$\alpha' = (e_i', e_{-i}^*) \text{ A} \quad (2)$$

$$x(e^*, \theta)) - \alpha' + 0(e_i' - e_i^*) \leq s_i(x(e^*, \theta)) - s_i(\alpha')$$
$$\sum_i (x(e^*, \theta)) - \alpha' + 0(e_i' - e_i^*)) \leq \sum_i s_i(x(e^*, \theta)) - \sum_i s_i(\alpha') A \quad (3)$$

Since α'converges to x(e*,θ):

$$\sum_i (x(e^*, \theta)) - \alpha' + 0(e_i' - e_i^*)) \leq 0$$
$$\sum_i (x(e^*, \theta)) - x(e_i', e_{-i}^*, \theta) + 0(e_i' - e_i^*)) \leq 0$$
$$\sum_i x(e_i^*, e_{-i}^*, \theta) - x(e_i', e_{-i}^*, \theta) + 0(e_i' - e_i^*) \leq 0$$
$$\sum_i -x_i'(e_i' - e_i^*) + 0(e_i' - e_i^*) \leq 0 \text{ A} \quad (4)$$

Since α'< x(e*) by the choice of α', and $x_i'(e^*) \neq 0$, the first term in the bracket is strictly positive. For large enough 1, this term dominates, which contradicts (A4).

Similarly, we can say that there are not efforts $\tilde{e}$ or sharing rules $\tilde{s}$ such that:

a) $\forall i, Eu_i(\tilde{s}_i, \tilde{e}_i, \theta_i) \geq Eu_i(s_i, e_i^*, \theta_i)$ and,
b) for some agent j,
 $Eu_j(\tilde{s}_j, \tilde{e}_j, \theta_j) > Eu_j(s_j, e_j^*, \theta_j)$

This form of the proposition in terms of expected utility seems more appropriate since there is production uncertainty in the model, and therefore, randomized shares. However, according to Chambers and Quiggin's state contingent approach of production under uncertainty, production under uncertainty can be represented as a multi-output technology, formally identical to a non-stochastic technology.

The same result as in the moral hazard case is sustained: as long as we insist on budget balancing (means 1 is satisfied) and there are externalities present $x_i' \neq 0$ we cannot achieve efficiency.

Holmstrom (1982) argues that there is a simple solution, however, at least under certainty. The free-rider problem is not solely the consequence of the unobservability of actions, but equally the consequence of imposing budget-balancing. If we relax (1) to read: $\sum_i s_i(x) \leq X$

$$s_i(x) = \begin{cases} b_i & if \quad x \geq x(e^*, \theta) \\ 0 & if \quad x < x(e^*, \theta) \end{cases}$$

Then there will exist efficient Nash equilibria (see Theorem 2, Holmstrom, 1982).

A scheme like this could be present in alliances with a manager acting as a principal who monitors and distributes equal shares among the firms and a team bonus to be shared if the output reaches the objective. This idea is related to Baron and Besanko's (1999) analyses of informational alliances. In their work, two suppliers of complementary products have an opportunity to form an alliance to consolidate their private information about their technological capabilities. The alliance between suppliers is assumed to be organized by a neutral fourth party that verifies the private information of each supplier. Within the alliance the disutilities are verifiable, and hence the agreement is internally enforceable even though the disutilities are not verifiable outside the alliance. Baron and Besanko (1999) explain, "the fourth party can be viewed as a fictitious modeling device that represents the reduced form of an unspecified bargaining process among the agents, in the spirit of Myerson and Satterthwaite".

4. THE RASMUSSEN MODEL UNDER HIDDEN INFORMATION

Under the contract e* is a Nash Equilibrium for some values of the parameter θ.

If output is x=x(e*,θ), let each firm i receive a share si such that the budget is balanced and condition a) is satisfied. If output is greater than x(e*,θ) (x> x(e*,θ)), split the surplus evenly among the firms after giving each firm i the amount si. If output is less than x(e*,θ) (x<x(e*,θ)), choose one firm j and let him receive –sj. Let each of the remaining (n-1) firms i receive $s_i + (s_j - x(e^*, \theta) + x) / (n-1)$. Depending on whether the unlucky firm is paid more than his marginal product in equilibrium, ($(s_j - x(e^*, \theta) + x)$ is greater or less than zero, and the lucky firms are paid more or less than they would have been had no one shirked.

The sum of the rewards when output is below the pareto optimal level and firm j is punished is:

$$\sum_{k=1}^{n} s_k = -s_j + (\sum_{i \neq j} s_i) + (n-1)\left(\frac{s_j - x(e^*, \theta) + x}{(n-1)}\right) = x$$

So that the contract is budget balancing.

To a single firm i which expects all of the other firms to choose the efficient effort level under each possible disutility of effort, the contract appears as:

$$s_i \quad \begin{cases} s_i + (x - x(e^*, \theta)) / n & if \ x \geq x(e^*, \theta) \\ s_i + (s_j - x(e^*, \theta) + x) / (n-1) & with \ p = (n-1)/n, \ if \ x < x(e^*, \theta) \\ -s_j & with \quad p = 1/n \ \ if \ x < x(e^*, \theta) \end{cases}$$

The difference between performing the efficient effort and lying must be positive. Thus yi>0, implies:

$$Y_i = [u(s_i - g(e^*, \theta)] - [(n-1)/ n * Eu(s_i + z_i) + 1/nu(s_i - g(\hat{e}, \theta)] > 0$$

Where e* is the efficient effort level, and $\hat{e}$ is an inefficient effort level.

5. THE CASE OF THE VIRTUAL FACTORY IN ST. GALLEN, SWITZERLAND

Neto (2006) discusses the concept of virtual organization and presents some paradigmatic cases of virtual organization. The case of the virtual factory in St. Gallen is one of them. This experience was coordinated by the University of St. Gallen that participated in the creation of the ITEM, Institute for Technology Management. This Institute counted on financial support from great transnational companies (such as: ABB, BASF, Daimler-Benz, Hewlett-Packard, KPMG, Philips) and some regional ones in order to make this virtual network possible. One of the main activities of the ITEM resulted in the technological integration of several small industrial companies, facilitating the creation of dynamic cooperation networks (virtual organizations).

Among them there are some manufacturers, that is to say, some virtual factories. In this case, the need for flexibility and lower response time to the excessive demand variations was verified. In this context, the combination of specialized industrial companies, each with its characteristic competence, becomes a highly viable business.

The operation of this company net follows the basic outline of the virtual organizations. A specific opportunity appears in the market, which can be, for example, meeting the orders of a large assembler, such as a steering gear. Some companies of the net join in.

Rallying competencies requires that small industrial companies temporarily unite to combine their forces in a concentrated effort to create a new solution for a customer. Thus, company A takes the responsibility for the design and for milling operations; this is firm A's level of effort; company B deals with the superficial treatment (hardening, coating, etc.), this is firm's B level of effort.

Disutility of effort in this frame refers to awareness and technology skills and knowledge in electronic markets, or what some authors called IT alignment.

Holmstrom (1982) indicates that in closed (budget-balanced) organizations like a labor-managed firm or a partnership, free-rider problems are likely to lead to an insufficient supply of productive inputs such as effort. To secure a sufficient supply of effort, companies should hire a principal to monitor the behavior of agents. Therefore, there are other actors in the virtual organization. The net counts on auditors that revise and inspect the projects; a network-coach, in charge of potential conflicts and seeking new partners' acquisition; brokers that, by means of a marketing policy of the existing capacities in each of the firms, try to attract customers' orders; communication managers, in charge of the necessary infrastructure for the transmission of data among the companies, and of competence, helping the specialization and development of its color capacities.

To achieve efficiency and relax budget balancing, we should permit group penalties that are sufficient to police all agents' behavior. Usually it takes the form of a flat share or profit and a group bonus to be paid if a target is attained.

Preliminary calculations indicate the reduction of costs of the products for the formation of the net, as compared to their isolation. The reduction results from the improvement of the process in the specialization of each of the factories. Thus, the company specialized in milling will probably obtain a smaller cost in the production of a milled component than another company without so much specialization in such an operation.

Although the firms' efforts or actions are observed, what the net cannot observe is the cost per firm of IT alignment.

The case study presented highlighted the formation of virtual factories near the lake Konstanz area, which increased from 7 to 32 companies in two years. This network was called EUREGIO. Firms select their task or core competence according to their type. The firms' efforts determine a joint monetary outcome, which must be allocated among the firms. Two products already manufactured in that area by the virtual companies were presented: an air sterilizer and a vehicle steering gear. The product or outcome depends on the firms' level of efforts and the states of nature, whether firm i is competitive or not.

Besides, the sharing rule specifies a firm i's share depending on the team output level.

According to the state contingent model, in period 0, the team commits its inputs. When nature reveals the state (high competitive level) which is beyond the scope of the firms, the firm produces the corresponding level of effort. According to this approach, the firms' efforts are the production technology inputs that depend on the states of nature, which are uncertain.

6. IMPLICATIONS FOR PRACTITIONERS

A virtual team output is conditioned by its members' efforts or core competencies, as well as by their disutilities of efforts. In general, these disutilities are unknown at the time of contracting and arise afterwards due to lack of experience in the application of the new information and communication technologies (ICT) that determines the competitiveness of the partners belonging to the network. This reflects the importance of learning for the virtual relationship. One of the disadvantages associated with virtual teaming is determining the appropriate task technology fit.

SMEs need appropriate and up-to-date ICT knowledge in order to compete. This ICT knowledge appears once the virtual coordination between members takes place. It cannot be acquired before contracting.

According to team theory, to achieve efficiency a virtual team should be coordinated by a principal or manager, who manages to monitor and control the core competencies and distributes equal shares among the firms.

Virtual cooperation is an alternative for small and medium sized enterprises to compete. While specializing in their core competencies, the virtual organization increases SME's competitiveness and promotes the extension of their market.

This study would help researchers, managers and policy makers to promote SME virtual teams. Unfortunately, little research on reward systems (compensation schedule) has been made with virtual teams. The type and level of rewards an organization offers influence the types of employees it attracts and retains (Gibson & Cohen, 2003).

7. CONCLUSION

This paper derives some conditions under which it is possible to implement an optimal sharing rule for a virtual team of SME under a hidden information frame. We consider the hidden information case as a special problem in inter-firm networks where members do not know their true costs or competitiveness levels. This information is privately known once the virtual team is working and the contract signed. The sharing rule can accomplish the objective of revealing the firms' competitiveness levels and the problem solving efforts of the group.

There is no fundamental difference with moral hazard models in the solution implementation to achieve efficiency. Milgrom (1987) had argued that the hidden information models apply equally when there is a hidden effort choice, and reversely. Thus, the objective of this paper was to adapt the existent contract theory under a hidden information frame since this type of incentive problems are present in SME virtual networks, where lack of information and knowledge of their members prevail. To accomplish the objective of team output observability, we apply the state contingent approach.

What is more, it suggests the need to continue providing formal approaches in this field of research, to close the gap between theoretical approaches and empirical evidence.

For future research, studies should consider the dynamic nature of virtual teams. Therefore, the efforts or tasks made by its members are likely to change over time. Moreover, the dynamism in virtual teams can affect the cost of effort. This dynamic may suggest the idea of learning in virtual teams.

Since the group of companies under virtual cooperation uses a computer network for the purpose of accomplishing some shared objective, they share the characteristics of a club. We can also argue that anonymity of a team's member, which relates to clubs, is a relevant characteristic in virtual teams. These considerations could be analyzed in the future, to join characteristics of teams and clubs into a unified theory.

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