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Technovation xx (2004) xxx–xxx

technovation

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Towards a knowledge management and learning taxonomy for research joint ventures

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Abstract

Research joint ventures (RJVs) are project environments that typically focus on the development of innovations and ideas. The development and management of knowledge is the primary objective for these RJVs. To help understand the practices and characteristics of RJV knowledge management and learning processes we introduce a taxonomy for these types of project environments. Using existing literature and supporting case study examples, a four-cell grid is developed to categorize RJVs. The grid is based on two dimensions, namely, the locus of the RJV research, which is concerned with the ‘newness’ of the knowledge, and the knowledge management approach, which is concerned with the learning and knowledge integration processes.

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Keywords: Research joint ventures; Knowledge management; Learning processes; Taxonomy

1. Introduction

Global competitiveness has put increased pressures on organizations that seek to maintain any form of competitive edge. Innovation and innovation capacities are necessary elements to manage and thrive in this environment. Over the last couple of decades, corporate emphasis on innovation has stemmed from such pressures as shorter lead times, mass customization, and the increased complexity and growth of technological advances. Organizations that institutionalize innovation and adopt an open and flexible attitude to change are better positioned in this type of market.

We view new knowledge (especially technological knowledge) as the foundation for innovation, change, and sustainable competitive advantage. Management gurus such as Peter Drucker have realized that knowledge has become the key economic resource and the dominant—and perhaps even an only—source of comparative advantage. Some scholars believe that competition is becoming more

knowledge-based and that the sources of competitive advantages are shifting to intellectual capabilities away from physical assets (Subramaniam and Venkatraman, 1999). Others suggest that while the creation of knowledge is important, the conversion of this knowledge into new products and services comprise the foundation of superior performance (Leonard-Barton, 1995; Nonaka and Takeuchi, 1995). The consequent implications of this notion for the way in which a business is operated and managed are far-reaching and dramatic, influencing everything from a company’s strategy to its products, from its processes to the firm’s structure. The term that has been applied to the early developments of this shift in perspective is knowledge management (Ruggles, 1998).

Knowledge management is still a relatively new area of research and thus consensus terms are still being formed. Corporate intelligence, memory, learning, information, and data, are all part of this knowledge management scheme. The interdisciplinary nature of this topic is relatively evident with the literature growing geometrically. A variety of fields are influencing this growth including computer science and information systems, organizational theory, management of technology, operations management, enterprise engineering, and systems analysis and dynamics, just to name a few. Part of the focus of this paper is on innovation and research and development (R&D), specifically within

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the context of inter-organizational practice and the relationship to learning and knowledge management.

Historically, firms organized R&D internally and relied on outside contract research only for relatively simple functions or products (Mowery, 1983; Nelson, 1990). Today, global competition, product and process complexity, along with technological advances, are forcing firms to rethink about how new knowledge is acquired. In an era where information and knowledge are increasingly entering center-stage, the task of developing knowledge has become more complex. It requires that an organization possess knowledge and skills in multiple technological fields that have to be upgraded constantly in order to meet changes in market conditions and customer expectations. Therefore, many companies cannot rely exclusively on their internal skills and knowledge in maintaining innovativeness and demand a range of intellectual and scientific skills that far exceed the capabilities of any single organization (George et al., 2001; Iansiti and West, 1997). At the same time, communication, collaboration and integration are required to maximize the synergy between the various interdependent elements (Moenaert and Souder, 1990; Hitt et al., 1993). This tension between specialization and integration seems particularly salient to the problem of technological development.

In recent decades, there has been unprecedented growth in research joint ventures (RJVs) in order to expand firms' knowledge bases and develop new skills. Many reasons exist, including competitive reasons, greater government support and industrial policy, and relaxed regulatory policies. Drucker (1995) suggested that the greatest change in the way business is conducted is the accelerating growth of relationships based not on ownership but on partnership. However, the success of this strategy in the long term depends on the proper integration of knowledge and learning developed during the R&D process. What gives a firm a sustainable competitive advantage is not only the knowledge set that a firm possesses at one point in time, but also the capability to create, integrate and use such knowledge.

Governmental support from various countries has arisen from the awareness of efforts that have attributed Japan's early competitive advantages to greater corporate R&D collaboration, some of which is subsidized by Japan's government. But, this issue is now broadening to international efforts by organizations. Some larger American companies are becoming increasingly reliant on the external technology obtained from collaboration with both domestic and foreign entities. Similarly, and given the importance of technological innovation, many governments, in order to help foster their country's competitiveness on a global scale, have been allocating an increasing amount of resources to inter-organizational collaboration for this purpose.

The literature on learning organizations sees research partnerships as mechanisms enabling firms to learn and enter new technological areas and to function more

effectively given technological and market uncertainties. As this statement suggests learning and knowledge are closely linked; where knowledge is a critical output of learning.

During the last 15 years, there has been a substantial increase in the literature on RJVs. While most of the empirical research has focused on four general issues: (1) trends in research partnerships, (2) composition and focus of research partnerships, (3) motives for participating in research partnerships, and (4) benefits from participation in research partnerships (Hagedoorn et al., 2000). We have observed that the gap in the literature and research available on these types of alliances and learning and knowledge management is particularly evident. Whilst knowledge management is a critical and central practice in research partnerships, managers and researchers have lacked models that they could use as guides in this environment.

To help bridge this gap of understanding and study, our paper develops a taxonomy of RJVs based on two knowledge management dimensions: the locus of the RJV research (which is further described below) and the knowledge management approach. Each of these dimensions and their theoretical constructs are described and later integrated into this framework. An initial evaluation and support of this taxonomy is completed using information and practices from case study projects. As part of this effort, we analyze whether differences in knowledge management and learning process (overall knowledge management approach) are related on the locus of the RJV. Initially, before discussing the dimensions in detail, an overview of RJV learning processes is presented. We view this background as important to the later dimensional discussions. This initial discussion will focus on characteristics of RJV learning, knowledge management creation and knowledge management transfer.

2. Research joint ventures, learning, and knowledge management

We define an RJV as a collaborative agreement in which two or more partner organizations (firms and/or public research organizations) decide to coordinate their R&D activities through a cooperative project and to share the knowledge generated from this joint effort. Each partner brings their own expertise to the newly created project in the hope that this combination of skills will produce benefits for all those concerned. By bringing together firms with different skills and knowledge bases, an RJV creates unique learning opportunities for the learning partners (Inkpen, 1998). This definition of RJV is similar to that of used by the Council on Competitiveness (1996) where 'partnerships are defined as cooperative arrangements engaging companies, universities and government agencies and laboratories in various combinations to pool resources in pursuit of a shared R&D objective'.

Thus, RJVs are seen as mechanisms enabling firms to learn and enter new technological arenas and to deal more effectively with technological and market uncertainty. Characterized by a network organization (an enterprise formed from separate organizations), its learning is described by a collective acquisition of knowledge among a set of organizations.

The literature on knowledge management distinguishes two core processes in the acquisition of knowledge for RJVs: (1) the creation of new knowledge through interaction among organizations and (2) the transfer of the existing knowledge from one organization to another (Larsson et al., 1998). Thus, the question confronting us now is how the individual partners must act to create this collective knowledge—the knowledge creating process—and how the RJV knowledge can be transferred to their own organization—the knowledge transfer process.

2.1. The knowledge creation process

The target of a process for knowledge creation is to enhance the potential of creating innovations as part of adaptive behavior in response to environmental pressures (Von Krogh et al., 2001). Many researchers have concluded that solving problems creates knowledge (Jaikumar and Bohn (1986); Hayes et al. (1988) and Pérez López (1991)). This conclusion implies that a RJV may recognize and define problems, generate and apply knowledge to solve problems, and further generate new knowledge through problem solving action (Nonaka et al., 2000). A RJV refines the understanding of its environment, increases its absorptive capability and improves its ability to react appropriately to future stimulus, by knowledge creation through problem solving.

RJV knowledge creation is not just an agglomeration of devices to gain access to an individual firms' knowledge. It should be more than a collection of individual experiences. Senge (1990) states that for learning to take place at a group level an alignment of the different individual learning processes is necessary to avoid wasted energy. From an organizational learning perspective, it requires a high degree of mutual involvement in problem recognition and problem solving processes. Partners must scan, notice and construct meaning about environmental changes. Initially, recognizing the existence of problems occurs when some stimuli indicate the need for new actions. These stimuli then lead to a second step, when partners jointly experience new work processes, tasks, technological characteristics, etc. to solve a problem.

Von Krogh et al. (2001) propose an iterative and multistage process for knowledge creation that obligate partners to spend considerable time together, discuss, and reflect upon their experiences, observe how their colleagues solve tasks and interact with technologies, explain, and give sense to their own actions. RJV members must establish relationships via language and thought in order to

coordinate their learning processes. Dialogue (Isaacs, 1993) has been identified as a key aspect of this integration process³. Each partner exhibits a perception or personal image of the world, and these perceptions will affect other firms when they are shared during interaction. Individual knowledge needs to be disclosed, shared and legitimized until it becomes part of the group knowledge. RJV knowledge is the result of the construction and interaction of numerous individual firm perspectives during problem recognition and problem solving processes.

Thus, we point out that creation of knowledge by a RJV requires three conditions:

- Communication, necessary for attaining a shared vision of reality and the actions that reality suggests.
- Transparency, since the communication processes and their results must be accessible and clear for all the organization members. Transparency presupposes the existence of a medium in which knowledge can be stored as principles, stories, a mission, and other symbolic elements, so that individuals can reflect upon them.
- Integration of the knowledge into the social system. If knowledge is to be accessible for the RJV, these individual organizations must be able to fully integrate their actions into a structure where they can participate and enrich their own individual development. The creation of a culture based on trust, in which individuals share information and experience, and propose initiatives to act in an unpredictable environment, is one of the critical aspects, although, at the same time, the most difficult to achieve (Goshal and Barlett, 1997).

2.2. The knowledge transfer process

The RJV knowledge creation process does not guarantee that individual partners benefit from such knowledge on a larger scale. Transferring RJV knowledge to individual organizations is another barrier for these projects. For this transfer to take place, it is essential that RJV knowledge is introduced and materializes in the operational systems of an organization, improving its activities.

Although a RJV is the means through which firms learn, the created knowledge needs to be communicated and integrated into its organizational routines in order to impact organizational effectiveness. Argyris and Schön (1978) have defined this as double-looped learning.

The intangible nature of knowledge assets prevents knowledge from being completely diffused and subsequently used in the organization, unless 'mental models' are simultaneously transferred. If mental models are not shared by members, changes in organizational routines and decision rules will not likely take place (Kim, 1993). Thus, the extent by which mental models are shared determine

³ The dialogue has been called 'the language of learning' (Nonaka and Takeuchi, 1995).

organizational understanding of the problem, fostering knowledge diffusion and facilitating its materialization.

Cohen and Levinthal (1990) express this idea in terms of ‘absorptive capacity’ which expresses the firm’s ability to assimilate new knowledge and make use of the benefits of joint research. Absorptive capacity contributes to innovation because it tends to develop cumulatively and builds on prior related knowledge. Given the intense cumulative nature of scientific knowledge, the firm’s knowledge prior to RJV participation influences the effective acquisition and utilization of new knowledge. Powell et al. (1996) have stated that knowledge facilitates the use of other knowledge. What can be learned (and thus generate new knowledge) is affected by what is already known. Then, organizations that possess relevant prior knowledge are likely to have a better understanding of the new knowledge, can generate new ideas and develop new products. Organizations with a high level of absorptive capacity are likely to harness new knowledge from an RJV to help their innovative activities. Without such capacity, they cannot learn or transfer knowledge from the RJV.

To accelerate knowledge transfer, three conditions should be satisfied (Nahapiet and Ghoshal, 1998). First, the parties are aware of the opportunity to exchange the knowledge. Second, the parties involved expect the knowledge transfer to prove worthwhile for both parties. Third, the parties must be motivated to pursue the knowledge transfer. Von Krogh et al. (2001) provide another knowledge transfer process. Knowledge transfer begins with the identification of knowledge to be transferred. Concrete learning targets are needed to integrate new knowledge rapidly from the RJV. Next, the receiver assesses the value of knowledge for local use, and the sender assesses the potential loss or gain. The next step covers packaging and dispatching of knowledge in such a way as to enhance the receiver’s potential to act.

3. Research joint ventures: taxonomic foundations

As previously stated, RJVs cannot be conceptualized as mere exchange relationships involving the transfer of products or services. A RJV differs from other kinds of collaboration because the primary motivation for joining a RJV is to gain new knowledge, which may be processed and transformed into a competitive asset. Underlying the RJV is the attempt to increase the knowledge base of the organization through a cooperative R&D project. We do not concentrate on separate knowledge characteristics in this paper but as an integrated concept within the general characteristic of the locus of the RJV. However, the success of this strategy in the long term depends on the proper integration of knowledge developed during the R&D process.

In this section we introduce some background on the two dimensions that will be used in our typology. The first

dimension will be the locus of the RJV knowledge and the second will focus on the method that knowledge and learning is integrated into an RJV and its membership. We have defined this second dimension as the knowledge management approach.

3.1. The locus of the RJV knowledge

The ‘locus of the RJV’ refers to the RJV project stage of technical development. Our definition has the main stages within this locus of technical development including: (1) *basic research* which searches for new concepts or scientific principles, although they may not present any direct application; and (2) *applied research* which utilizes acquired knowledge from basic research, showing its potential practical contributions to solve known problems.

In terms of knowledge, these two stages involve different levels of ‘radicalness’ of its learning process⁴. While applied research focuses on knowledge development from an existing body of knowledge, basic research seeks to construct and acquire new knowledge, adding to the body of knowledge.

Viewed broadly, technological change occurs in two extreme forms. In the first form, developing knowledge is derived from existing knowledge. In the second form, new knowledge is created with loose connections to existing knowledge. March (1991) expressed this idea of knowledge development and use in terms of exploration and exploitation. He argued that the essence of exploitation is the development firm’s current competencies and the essence of exploration is experimentation with new alternatives.

Exploitation involves less radical characterizations defined by such terms as refinement, choice, production, efficiency, implementation and execution. It uses conservative and routine processes that maintain stable relationships. In contrast, exploration includes more radical characterizations such as variation, risk taking, experimentation, flexibility, discovery, and innovation (March, 1991). Likewise, exploration is characterized by the re-orientation of routines and process and the search for new rules and goals instead of developing existing routines in a more efficient way.

As outlined above, it seems that RJVs face a trade-off between focusing on existing knowledge, (exploitation) which may be more effective in the short-term or focusing on new knowledge, (exploration) which is typically required to be successful in the long run (March, 1991). However, other researchers (e.g. Mezas and Glynn (1993)) recognize that differentiation between exploration and exploitation can be rather ambiguous. That is, most R&D projects require both the generation of some new knowledge and the application of some pre-existing ideas.

⁴ This concept is related to innovation radicalness, which has been discussed by others (e.g. Tushman and Anderson, 1986).

3.2. Knowledge management approaches for RJVs

In the knowledge management literature, the exchange of information and the organization of collaboration are a means of facilitating the integration of R&D. While face-to-face transfer is usually associated with the transfer of tacit knowledge, written documents are mechanisms more associated with explicit knowledge.

Shrivastava (1983) pointed out that knowledge management varies in terms of systematization, normalization, complexity and relevance in the decision making process. Hansen et al. (1999) observed that firms employ two different knowledge management strategies, codification strategy and personalization strategy. In some companies the strategy centers on the computer information system (codification). Knowledge is carefully codified and stored in databases, where it can be accessed and used easily by anyone. In other companies, knowledge is closely tied to the person who developed it and is shared mainly through direct person-to-person contact (personalization). The chief purpose of computers at such companies is to help people communicate knowledge, not to store it. Underlying this classification is the idea that knowledge management involves: (1) a 'tangible' and structural aspect that integrates formal working factors and (2) an 'intangible' social aspect that combine factors such as intuition, spontaneity and values or beliefs associated with human development. Jones and Handry (1994) argued that the development of the learning capacity demand both, structural or technical aspects related to explicit knowledge (hard learning), and social or human aspects more related to tacit knowledge and thought styles, (soft learning).

As a natural extension of how firms manage knowledge, an RJV may not take a uniform approach. Both knowledge transfer and creation require simultaneous structural and human aspects. The social approach of knowledge management focuses on the processes of collective language development and joint understanding, without which no existing knowledge is disclosed and thereby cannot be received by other partners or used collectively. The structural approach emphasizes the acquisition and distribution of the needed information to absorb the disclosed or generated knowledge.

RJV learning is therefore a joint outcome of the interacting organizations' choices and abilities to more or less acquire and absorb information—the structural perspective—and understand and use that information on the creation of new knowledge—the social perspective. These dimensions can serve as a continuum.

4. A two-dimensional taxonomy of RJV knowledge management

We now present a two dimensional taxonomy by which RJVs may manage their R&D activities and for sharing

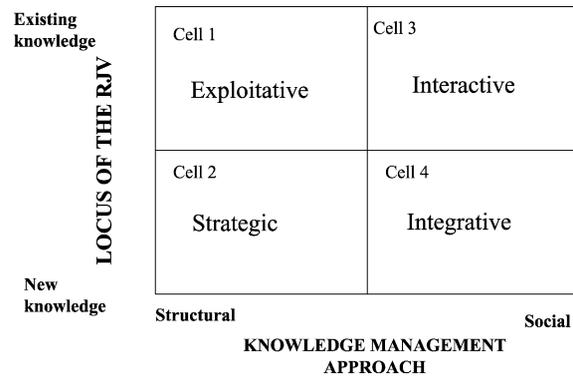


Fig. 1. A two-dimensional taxonomy of RJVs and knowledge management and learning processes.

the knowledge generated by the RJV. Although much of the learning literature addresses the product or content of learning, the management of the learning and knowledge process is also important. A focus solely on content ignores the complex cognitive and behavioral changes that must occur before a learning 'outcome' can be identified (Inkpen and Dinur, 1998).

Thus, it is possible to define two critical dimensions that permit us to present a more suitable taxonomy of RJVs. These dimensions are summarized in Fig. 1. The first dimension, the locus of the RJV, is focused on the stage of technological development at which the RJV operates. This vertical axis delineates R&D projects that use existing knowledge—more tacit, specific and systemic—to solve problems (applied research) and those that generate new rules and knowledge—more explicit, generic and autonomous—to deal with a new problem (basic research). The second dimension relates to the knowledge management approaches that support the inter-organizational learning process. The horizontal axis measures the extent to which the RJV focuses more on structural practices versus social practices to create and transfer knowledge. Four cells are identified in this taxonomy, which we have defined as exploitative, strategic, interactive and integrative. Each of these cells is further embellished with exemplary cases of actual RJVs. For the sake of anonymity we do not name companies in these cases.

4.1. Exemplary taxonomy cases

4.1.1. Cell 1: exploitative RJVs (existing knowledge—structured learning processes)

Cell 1 RJVs develop R&D projects that are focused on existing knowledge and manage the learning process in a structured way. Knowledge management basically lies within tangible structures and procedures that efficiently capture and retain the learning of the project and disseminate it to partner organizations within an RJV. R&D projects are oriented towards achieving efficiency in operations as well as reducing risk in operations. It increases the organizational capability of maintaining an organization's competitiveness

with their current task and markets. In this situation knowledge transfer, rather than knowledge creation is essential to the consolidation of activities as well as competencies.

A good example of this RJV type is a project between a world-class shipyard, a consulting firm, an information technology company and a mechanical engineering department of a University. The purpose of the project was to define, develop and introduce practical procedures, methods and tools to enable different operators within the shipping community to design, maintain and operate ships and ship systems with high safety, balanced availability and low owner cost characteristics. The procedures, methods and tools focused on areas of: information management, logistics support, safety management and quality assurance, maintenance and maintenance management, system design, cost-benefit and life cycle costing.

The project's goal could be summarized as follows, extend the ship's life. Anything that could extend the ship's life with information technology was considered. Overall, this goal was quite broad. This ambiguity was the reason for the first phase of the project was a market analysis, to help further select the priorities and needs of the shipyards' customers and to more clearly define the project scope.

This project was completed in three overlapping and iterative phases. Initially, the state of the art and the expected potential for improvements in the shipping community were discussed, including lower probabilities for safety related failures and accidents, lower probabilities for failures in ships systems which are related to the timely operation of ships, lower cost for scheduled, and unscheduled maintenance of ships and ships systems. The findings and experiences from this analysis were summarized and transformed into specifications for development of suitable procedures, methods, and tools. These specifications were turned into recommendations for the practical introduction and application of suitable methods, procedures and tools for improving safety and availability and to reduce owner's costs. Adaptation of available products was used to improve some of the identified deficiencies. Most of them were composed of available software that was adapted to the specific need.

This R&D project could be considered central for the shipyard's core activities, since this firm is concerned about quality and continuous improvement. Its participation on this RJV was to control future improvements to extend the ship's life. Likewise, the information technology company wanted to develop a product of general utilization in this sector that later could be implemented by other organizations.

This RJV was conceived as a useful tool to aid knowledge transfer. Thus, the RJV defined structural mechanisms (relevant information, documents containing operative solutions, value propositions, technical specifications, programming documents) to be sure that the captured knowledge can be disseminated to other R&D projects or

applications. The shipyard company provided expertise in the state of the art of design and production of ships. This knowledge was considered very useful for the identification of needs, possibilities of improvements and new development in the shipping community. The information technology firm and the university participants combined research and practitioner experts, especially in information technology, to solve operative problems for improving safety, availability and cost reduction. This RJV project resulted from local adaptation of tools, methods and processes invented and developed elsewhere. By sharing knowledge in this way, the probability of 're-inventing the wheel' is significantly reduced. Likewise, the easily available documentation avoided the need to spend time tracking down information and allowing the RJV to work more efficiently.

4.1.2. Cell 2: strategic RJVs (new knowledge—structured learning processes)

These types of RJVs support the building of new knowledge, but with a focus on capturing and transferring knowledge from the RJV to the partners. The difference from a cell 1 RJV is that here the knowledge is not pre-existent. Despite this characteristic, new knowledge is structured and applied according to existing and structured processes. Because the new knowledge in this classification does not pre-exist within the firm, the key challenge is to effectively transfer the new knowledge. These RJVs aim at developing future competitive advantages and thereby enhancing the internal capability to face future changes. The benefits are rarely appreciable in the short-term.

An example RJV that would fall within this cell is an R&D consortium created to develop a new concept, 'The Multimedia Broker'. This concept provides an infrastructure for publishers to more easily work with their publication authors and to provide their customers with the tools to query the networked products offered by the publishers.

In this context, this project aims at integrating multimedia information retrieval techniques, visual query systems, a federated systems architecture, and transaction systems to provide a service. The system will be constructed with a web-based infrastructure as the foundation.

This R&D project was designed to be an integrated system of a number of independent subsystems, each of whose development was assigned to one of the partners responsible for technical solutions. Physically, each development partner was going to work independently, with the commitment to satisfy the agreed upon deadlines for the design and implementation. Electronic mail and the introduction of a system for cooperative work allowed technicians working in three different countries to maintain close cooperation and exchange results. Once the subsystems had been specified, the task of the RJV was to define its interactions and interfaces.

The RJV also defined a work methodology. The work methodology chosen focused on rapid prototyping.

Rapid prototyping requires any results to be rapidly translated into an integrated prototype including all independent parts and to proof the whole system functionality. Likewise, at the beginning of the project a quality plan was decided upon by the RJV management on the software to be developed. The quality plan for software included the definition of nomenclatures, the comments to be included in the program and the testing procedures to be used. Its aim was to facilitate the integration of the independent efforts of the RJV.

Another important RJV issue was the allocation of the property rights of the results between the different members of the RJV. It was decided that the technical members would have the exclusive property of the parts developed by each one of them. In addition, participation in the consortium provided the limited right to all partners to use any of the results obtained by the project.

These kinds of RJVs help their partner members attain innovation goals while at the same time sharing the risk of obtaining short-term profitability from new technologies, especially in the initial stages of their development. In this case, the multimedia broker led to detection of areas for technological innovation with the highest possibilities of applications to the business environment. The members of this RJV only become involved in research projects if the results offered innovative solutions to their clients. Thus, although the RJV must be given the responsibility for creating new knowledge; they were more focused on the definition of the interactions between the partners for capture and transfer of knowledge than in the knowledge creating process, which was the responsibility of individual members. This means that once knowledge is created the likelihood of capture is very high.

4.1.3. Cell 3: interactive RJVs (existing knowledge—social learning processes)

Cell 3 incorporates RJVs that increase the scope and depth of existing knowledge by socializing members around certain problems, task, and work processes. Knowledge gaps between the members indicate the need to seek new insights, and invest time and energy. Since developing knowledge requires existing experience and knowledge, RJVs build up competencies and skills that, locally applied, generate a better understanding of the key processes or variants of existing products.

A good illustration of this type of RJV is an alliance created between a large multinational company that develops urban maintenance innovations such as garbage collection, public road cleaning, elimination and treatment of garbage, conservation and cleaning of green zones, building, integral cleaning and sewage network maintenance and, one of the largest industrial truck manufacturers in the world. Its aim was to develop two electric hybrid prototypes of refuse trucks that can operate with minimum noise and emission pollution when collecting garbage within congested areas of large European cities.

Since the early 1990s, the partner in the RJV charged with urban maintenance was concerned with town councils' interest in environmental topics. These interests were especially important for pollution and noise emission related issues facing collection trucks in difficult to access areas, such as historical places. To be competitive in such a sensitive market this company firmly believed that the most advanced technologies had to be incorporated into its services. They were unsatisfied with the performance of the fossil-fuel based gas engine trucks in reducing gas emissions and noise in difficult access areas. Thus, they concluded that it was necessary to improve upon and experiment with other types of vehicles, especially hybrid trucks that combined the electrical and diesel motors. Once the RJV undertook the challenge, the objective was clear: the task was to obtain a hybrid vehicle with the same service level as a diesel vehicle and with no noise and gas emission.

With the RJV goal determined, this company contacted the truck manufacturer to organize a work meeting focusing on the prospects of jointly defining and creating a vehicle that fulfilled the stated objectives. The previous work experience was a determinant for the selection of this partner as the technological collaborator for this new R&D project.

The technology that was to be developed gave the truck manufacturer the opportunity of enabling its managerial staff to build on future breakthroughs in the market, while sharing fixed costs of the R&D of a particular type of vehicle with its clients. In addition to this issue, it provided the possibility of utilizing generic knowledge developed at a scientific level to better satisfy the customer's needs and to improve the relationship with them. Even though the development of this knowledge is vital to the truck manufacturer's core activities, the complexity and the high cost of its development, along with low prospects of large demand, prevented the company from developing the project on its own.

Once both the companies expressed their interest in the R&D project, a collaboration contract was signed. With respect to the property rights on the results of the project, the truck firm would hold the rights on the developments and provide access to the results to the urban maintenance firm for a stipulated time period once the contract ended.

Based on the existing technology, the RJV began with the analysis and assessment of any hybrid vehicle. The results were obtained through joint work that was completed between the two companies. The urban maintenance firm provided the experience from their 4000 garbage collection trucks and its knowledge about the demands of final users, in this case the town halls. In light of these expressed requirements, the truck company was set to design the truck.

The construction of the prototype was complex and subject to continuous modifications. One of the participants stated that eventually more functions than initially required were added to the vehicle. The urban maintenance firm participated actively in this stage as the client company that

was going to use the developed product. It provided knowledge about loading, the work cycles, energy consumption and other technical specifications.

When the first prototype was finished, it completed a thorough test to detect further possible improvements. In order to complete the test, the urban maintenance firm took over this stage by driving garbage collection trucks through difficult access areas in towns. Simultaneously this prototype was presented at trucking fairs with the purpose of collecting surveys about the interest that had arisen.

With the support of the accumulated knowledge of this prototype, improvements were determined and were assessed by the multidisciplinary team integrated by members of the two companies. Some proposals were implemented during the test. Other proposals required that the vehicle be taken back to the manufacturing site. The feedback cycle between technicians and the customer ended at this test stage. The success of the first vehicle prototype eased decision making for further modifications.

When the second prototype was finished, the urban maintenance firm began to include the option of using this vehicle for urban services maintenance in its competitive bidding clauses. This way it increased the market awareness of environmental issues and made it clear that the hybrid vehicle was a reality. Likewise, the close results of this collection hybrid vehicle to what was demanded by the customer has allowed the truck company to exhibit its capabilities in meeting specific and sometimes complex customer needs.

The main difference of this kind of RJV with respect to the two previous groupings of RJVs is the emphasis on joint work and greater (even contractual) interaction between the partners. Meetings and personnel transfers were included in the means of interacting and for exchanging knowledge. These stronger interactions between customer and supplier also created a basis for broader, more extensive interaction. In fact, the consolidation of this relationship caused the maintenance company to opt for this truck firm as manufacturer of a second-generation collection hybrid truck.

4.1.4. Cell 4: integrative RJVs (new knowledge—social learning processes)

Finally, cell 4 includes RJVs that seek the biggest competitive advance, who encounter the largest risks due to the more intangible nature of the project. They develop R&D projects that seek to construct and acquire new knowledge and manage the learning process with a social approach, based on innovation, creativity and trust. Here knowledge creation is something different when compared with RJVs that fit within cell 3. In this situation there is no available knowledge where you can judge the relevance for further expansion. In some ways, these RJVs become ‘corporate revolutionaries’ that, with an entrepreneurial behavior, create knowledge that can become imperative to long-term performance. Although creating new knowledge

is always risky because it breaks the existing linkages between the new knowledge and the prior knowledge, it produces the largest potential for learning, which may, for example, change the definition and direction of whole market segments or bodies of knowledge.

In order to illustrate these kinds of RJVs we present a research agreement between several companies operating in the telecommunication industry. We identify two kinds of companies in this RJV: telecommunication operators and telecommunication equipment providers. One of the telecommunication operators had perceived a large demand for automated teller machine (ATM) services and wanted to control future developments in this field. With the idea of developing an ATM switch with lower cost and bigger capacity, which will be able to support a wide range of services. The project needed to identify participants that had a good reputation in terms of their previous knowledge base in ATM switches and were very interested in completing new work related to ATM. Therefore, firms with the same ATM interest and a good knowledge base on this issue joined efforts within this RJV.

Since this RJV was focused on radical and breakthrough innovation more than incremental improvements, the partners saw themselves rather as complementary parts than as rival firms. That means that although they operated in the same markets, in the absence of any apparent rivalry in the short run, the threat was sensed as a long-term concern with no immediate competitive issues that would arise.

In order to define the specifications of the future, a third generation of chips for ATM switches, it needed to gather information about user’s requirements, review telecommunications standards, and identify the specifications of the ATM switch chip. Because this was a radical innovation beyond mere variants of existing products or technologies, the project was subject to continuous modifications. One of the participants stated that eventually more functions than initially expected were added to the ATM switch chip. The need for continuous consideration of new data, insights, concepts, required a very close inter-company collaboration between the technical staff. The mediums of communication used were electronic mail, fax, telephone, onsite, and offsite meetings.

Creating new knowledge is always a risky activity, even when there is cost sharing for development between the partners. During the project, regulation of the telecommunications sector changed and the operators were not allowed to offer ATM services. When this happened the RJV partners lost interest in chip development for ATM switches and this project. As a result, the customers of these of services looked to other technologies to satisfy their needs, for example, network Internet providers (IP). The less expensive IP network was chosen for providing, if not all, at least part of the services that initially were reserved for ATMs. The problem with the IP network is the low quality of the service offered by them. Even though the ATM offered better quality it was also more expensive.

However, as time went on, the quality problems of the IP network were more evident and the interest in the chips ATM switch increased. When this situation became clear the partners decided to reinvigorate and continue with the R&D project. Because these kinds of RJVs do not pay much attention to knowledge transfer issues and the exploitation of knowledge, during the time in which the project was on hiatus due to uncertainties and doubts about the future of ATM technology, a deterioration of the knowledge generated by the RJV resulted with a need to rebuild some knowledge and information.

5. Managerial and research implications of the taxonomy

The purpose of any taxonomy is to try to make sense of and further develop evolving ideas and their relationships. In our taxonomic approach we utilized literature in the area of RJV, R&D, knowledge management, and learning processes research to arrive at a taxonomy that can help to further understand how RJVs operate in managing their knowledge and learning processes. From a R&D project management perspective, identifying the relationship of an organization and its RJV will have implications on what can be expected in terms of outcomes and what factors play a role in succeeding in a particular environment, especially with respect to knowledge creation and transfer. If an organization is faced with the search for new knowledge in a very social process, they will have to realize that intangible relationship development and high risks may be associated with the R&D project with a strong possibility of little short-term benefit. Having an organizational system that can function in the specific RJV environment, developing the appropriate expectations, and communicating them to personnel, will be necessary. For example, from a human resources selection perspective, R&D project managers who may be more task oriented may not fit well within a cell 4 RJV environment, while they may flourish in a cell 1 RJV environment.

Developing the appropriate infrastructure and communication protocols may be central to the success or failure of different types of RJVs. An integrative RJV would require significant social settings and face-to-face meetings to make progress such that trust and sharing can occur. Also, the performance metrics used to evaluate different RJVs will influence the definition of what a success or failure may be. If the focus is on the exploitative cell, relatively short-term performance metrics, e.g. actual products marketed in a year from RJV knowledge would be appropriate. Whereas in the strategic RJV it may be inappropriate to measure products to market in a given year from this type of RJV. Other examples do exist and have been mentioned in terms of managing an individual organization or group of organizations in this environment in our background discussion.

What this taxonomy can explain and what it cannot explain requires additional research. No taxonomy can incorporate all the various dimensions of a project environment, especially as one as complex as RJVs. Yet, this taxonomy can be evaluated empirically by determining how well it can discriminate among potential RJVs and firms. Its development was based on research literature and a number of actual cases that have been observed by the researchers. Yet, empirical, scientific study of various RJVs is clearly necessary to help determine how well this taxonomy can explain the operations, performance, and project management characteristics of RJVs. Of course, since the focus is on the more intangible and difficult to measure knowledge management and learning processes of the RJV, rather than the content of the RJV, operationalization of factors and indicators to measure these dimensions is not a trivial exercise. For example, indicators for levels of social processes may require some proxy definitions and observations. Discriminating factors between what is a social or structural process, and what is new or existing knowledge will need to be defined and tested. We view this issue as complex since many times RJVs fit a spectrum of dimensions and what may be new to one organization may be existing knowledge to another.

Thus, we see that there are limitations that may exist. Testing this taxonomy is the next step of any research agenda. Yet, it does provide a means by which researchers and managers can use to help make sense of RJVs knowledge management and project management.

6. Summary and conclusion

In this paper we have focused on a topical area that is of growing interest to organizations, practitioners and researchers in the knowledge management, R&D project management and R&D fields. Many innovations that are being introduced have arisen from RJVs, it is expected that with increased complexity of technology, products and services, and the acceptance of further collaborative organizational efforts, these RJVs will only increase in popularity. Making sense and understanding knowledge management and learning processes within these types of collaborations has been quite limited. This paper provides a means to help set a foundation to understand these collaborative efforts.

Using a variety literature in managing these collaborations from numerous fields and sources, we introduced a taxonomy. Using practical and actual case studies, we exemplify how relationships within these taxonomies may work. Managerial and research implications were provided, with the eventual conclusion that the taxonomy can help managers plan for these types of projects and help researchers develop a simple, yet useful, model to evaluate these projects. Future research related to testing the taxonomy with broader data sets is still required.

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