Knowledge Management in the Forest Products Industry: the Role of Centres of Expertise

Constance Van Horne, Jean-Marc Frayret, Diane Poulin

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Research Consortium in e-Business in the Forest Products Industry (FOR@C)

Network Organization Technology Research Center (CENTOR),

Université Laval, Québec, Canada

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Constance Van Horne[1], Jean Marc Frayret[1] [2]* and Diane Poulin[2]

[1] FOR@C Research Consortium, Pavillon Pouliot, Université Laval, Quebec City, Quebec G1K 7P4, Canada
[2] CENTOR (Network Organisation Technology Research Centre), Université Laval, Quebec City, Quebec G1K 7P4, Canada

- Corresponding author: jean-marc.frayret@forac.ulaval.ca

Abstract

This paper is a critical review of knowledge management in the forest products industry and uses the framework of the knowledge value chain to outline the authors' findings. This chain is generally accepted as being the network of processes that increase the value of knowledge as it progresses from data to innovation. To face the challenges of a knowledge based economy, forestry companies need to be aware of how knowledge is created and disseminated. There are numerous centres of expertise at work in the world wide forest products industry. The authors suggest that the role of these centres is not just to create information and knowledge, but also to efficiently disseminate their findings to the industry. The case study of the FOR@C Research Consortium based in Quebec City, Canada is introduced as an example of the role that centres of expertise can play.

Key words: centres of expertise, forest products industry, knowledge management, knowledge value chain

C. Van Horne is a Research Professional with FOR@C, Université Laval

J.M. Frayret is a Professor with the Faculty of Forestry and Geometrics, Université Laval

D. Poulin is a Full Professor of Management at the Faculty of Administration Sciences, Université Laval

1 Introduction

The forest products industry finds itself compelled to react to mounting pressures resulting from globalisation. The pressure is manifested as heightened competition and the demand for sustainable development from governments and customers, which requires new approaches to manage and transform natural resources. The industry is also responding to the increasing importance of new technologies. These technologies make real time information accessible to all and collaboration across organisational boundaries easier. In order to succeed in this new economy based on knowledge, the industry needs to be innovative and develop new competencies.

Contrary to a popularly held belief, the forestry sector is not simply concerned with the maximum exploitation of raw materials using highly productive machines and an uneducated workforce. In fact, it is an active participant in the knowledge revolution (Simard, 2000) and is making a move towards sustainability (Innes, 2002); through a business plan built around a triple bottom line that includes economic, environmental and social considerations (De la Roche and Dangerfield, 2002). While perhaps slower than other industries to grasp the extent of this revolution, the forest products industry has responded to these new social and economic contexts. Four major trends have emerged in the forest products industry: (1) restructuring, consolidation and search for profitability, (2) cost reduction through production optimisation and technological innovation, (3) a customer orientation, centred on differentiation and adding value and (4) the confronting of environmental challenges (Juslin and Hansen, 2002). These trends reflect those of other industries, but the entrenchment of outdated business models and methods, at least in the North American forest products industry, has resulted in a somewhat slower process than in other industries.

Larger companies, often integrated along the supply chain (from forest to client), have emerged around the world. Before this time, the industry was fragmented. This fragmentation led to overproduction, price wars and the incapacity of the industry to manage its own trends (Juslin and Hansen, 2002). The fragmentation also led to consolidation and a reduction in production capacity from the closing of mills. At the same time, costs have been reduced through process optimisation and product innovation. This innovation has been the result of capital investments in research and development in diverse fields from industrial engineering, to geomatics, to biology to name just a few. Injections of capital have also been made on new equipment and machines built on sophisticated technology. These technologies and R&D spending have allowed the industry to become more flexible and reduce manufacturing delays, thus increasing productivity (Juslin and Hansen, 2002).

As the industry needs to constantly improve service to its customers, companies must consider their entire value creation network, focussing on the “whole systems” perspective. This perspective begins with land use planning, followed by timber harvesting, transportation and manufacturing and ends with the delivery of the final product to the consumer (Innes, 2002). Traditionally, in North America, the forest products industry has pushed production along the value creation network. However, companies are increasingly attempting to mix a pulled component, in direct response to customer demand, into harvesting and production processes. Finally, there are three

aspects about the environment that directly concern the forest products industry: environmental management (ISO 14000 sets environmental management standards), forestry certification and environmental labelling (Juslin and Hansen, 2002). Concern for the environment and auditable products are becoming more than just customer fancy. Entire markets are requiring companies to prove that their products do not come from, for example, old growth forests, and that responsible harvesting practises were used.

In such a context, it has been said by the Canadian Forest Service that the ability to learn faster than the competition might be the only sustainable competitive advantage left (Simard, 2000). This paper addresses that issue and looks at how knowledge management and the knowledge value chain can be used to help companies operating in the forest products industry react to the challenges and trends described above. The role of centres of expertise will then be addressed.

The first section of this paper will present a general overview of the concepts of knowledge management, knowledge value chains and knowledge supply networks as they apply to the forest products industry. The second section elaborates generic models of how centres of expertise can lend support to the industry to manage its knowledge value chain. It then provides a specific example of the FOR@C Research Consortium in e-Business in the forest products industry. The Consortium is based in Quebec City, Canada and is concerned with the Canadian forest products industry.

2 Knowledge Value Chain and the forest products industry

A global trend in reaction to industry pressures has been the development of the management of value added networks. It encompasses practices and methods for the purpose of delivering the right goods to the right location at the right time. Knowledge management is another alternative that companies use to relieve the pressures of the new economy. It entails getting the right information to the right people at the right time, so that they can use that information and turn it into knowledge. That knowledge can then be used and shared to add value and new competences to the company, with the ultimate goal of contributing to innovation and increased profit.

Just as a coordinated and well-managed supply network results in efficiencies, and can even become one of an organisation's competencies, so too can a coordinated knowledge value chain. A knowledge value chain has been defined as a flow of knowledge through a sequence of processes in which its value is increased at each stage (Simard, 2003a). Various general models have been applied to diverse industries. In the forest products industry, Simard (2003b) uses a model of four separate knowledge value chains, which are:

- knowledge creation
- knowledge use
- knowledge management
- knowledge preservation.

In contrast, Lee and Yang's (2000) knowledge value chain consists of the knowledge management infrastructure, knowledge management process activities and knowledge performance. A similar concept, knowledge supply networks (KSN), has been presented in the electronics industry (Mak and Ramaprasad, 2003). A KSN is an integrated multi-company set of competencies, which exploits the knowledge needed to design, manufacture, market and distribute a product. As decision making becomes more complex, timely "delivery" of specialised knowledge becomes more crucial (Schmoldt and Rauscher, 1994). Consequently, it is entirely valid that these knowledge management models are built on a supply chain structure.

This paper will describe generic models of the knowledge value chain and knowledge supply network and apply them to the forest products industry. An adaptation of the knowledge value chain will be used as follows:

- data to information;
- information to knowledge and knowledge transformation;
- knowledge to dissemination;
- dissemination to application;
- application to innovation.

Both models will be particularly useful in analysing the role of centres of expertise.

2.1 Data

Data comprise the first step of the knowledge value chain. They are recorded observations and measurements that carry information. However, data must be interpreted in order to extract information (Simard, 2000). Data can come from the forest, government organisations, centres of expertise, scientists, employees, customers, etc. The key to data is managing it. When it is managed, data will be timely, accurate and available when and where it is needed. This is most effectively accomplished through information systems that can access internal and external data sources and then sort and tailor the data to the needs of the user.

In order to be used by a company, data needs to be available, accurate, valid and distributed to the right people (Davis, 1993). When companies are restructured or consolidated, much data becomes obsolete and this can hinder knowledge management efforts. The cleaning up of company databases and the removal of outdated data is an important part of a knowledge management system (Cook, 1999). In order to create a valid and effective knowledge value chain, the data must be well managed. Therefore, procedures (incentive programs, data verification…) need to be developed to ensure that data is entered into systems and that it is accurate.

2.2 Information

Information is data with meaning and value added. It has been put into context, categorised, classified, corrected and condensed (Seng *et al.*, 2002). It is data that has been organised, tabulated and made useable. It is the "what" of knowledge. It must be noted that one person's knowledge can be another's information. This is because if a person cannot understand or apply their tacit knowledge to information, there is no added value and therefore no knowledge created (Lee and Yang, 2000). In a similar way, Schmoldt and Rauscher (1994) point out that even if someone believes a piece of information to be true, there is no knowledge without proper justification of that information. For example, a workshop developed for supply chain professionals would not have the same effect if it were given to first year industrial engineering students. Common knowledge for the professionals would be unusable information for the students. Information given would remain information, as most students would not have the know-how to understand and apply it to create knowledge.

Information management is most efficiently accomplished with the use of technologies such as data processing, database management and information systems (Simard, 2000). Simard (2000) describes the forest products industry as "drowning in information and starving for knowledge". Often, not being aware of what a company knows is the biggest problem. Because of this, there are various questions that need to be asked and answered by organisations. How do we coordinate our information? What information do we need? Who has this information? Where can we gather it? After these questions have been answered, we need to ask: how do we manage information so that it adds value to our products, services and processes?

How can organisations in the forest products industry determine the information that they need to survive? Also, how can they know who possesses that information? In industries based on natural resources, information is never complete and is subject to change. Moreover, environmentalism has increased the importance and the need for auditable products. Certain consumers need to know that their newsprint does not come from old growth and uncertified forests. The only way for organisations to assure consumers is through information management systems that trace the origins of raw materials throughout the processes of transformation and distribution.

2.3 Knowledge and knowledge transformation

Knowledge is information that has been read, understood, interpreted and applied to a specific work function (Lee and Yang, 2000). There are two types of knowledge: tacit and explicit. However, it is extremely rare to find absolutes in either. Tacit knowledge, also called procedural knowledge, is personal and difficult to formalise. It is our hunches, insights, know-how and cognitive knowledge and is based on our beliefs, ideals, values, schemata and mental models (Nonaka and Noboru, 1988; Nonaka, 1991; Schmoldt and Rauscher, 1994). According to Cavusgil *et al.* (2003), tacit knowledge forms the foundation for building sustainable competitive advantages. Explicit knowledge, also referred to as declarative knowledge, can be expressed in words and

numbers and shared in the form of data, scientific formulae, specifications, manuals, reports, etc. (Nonaka and Noboru, 1988; Schmoldt and Rauscher, 1994).

Tacit and explicit knowledge in the knowledge value chain can either be available too early, just in time or too late. It is a perishable item. If knowledge is not used or distributed in a timely fashion, its worth could be greatly reduced. Furthermore, if knowledge has become inaccurate, it might actually be detrimental for the organisation that uses it (Nonaka and Noboru, 1988; Nonaka, 1988; Cook, 1999). Knowledge creation is the spiralling process of interactions between explicit and tacit knowledge (Nonaka and Noboru, 1988). For these authors, there are four types of knowledge innovation: socialisation, externalisation, combination and internalisation.

Socialisation is the transfer of tacit knowledge between individuals. It can be done through joint activity, apprenticeship and the capturing of knowledge through physical proximity (watching and learning). The transfer of one employee's or an organisation's tacit knowledge to another's is an important aspect in the successful consolidation of companies. The tacit knowledge of the merged companies and their employees must be shared in order to ensure the smooth and seamless integration of processes between the two organizations. This is also important for the training of employees with new procedures.

At the operational level of the forest products industry, knowledge concerning the use, transformation, and treatment of wood is mostly tacit (e.g. wood grading and wood drying control expertise). Consequently, it is important to promote tacit knowledge exchange between employees in order not to loose this valuable resource. The process of operations planning, when it is not formalised into an explicit computer system, may be considered as tacit know-how as well. This is even more appealing to the industry due to the heterogeneous nature of wood that has a great impact on its transformation.

Externalisation is the transfer of tacit knowledge to explicit knowledge. In this way, tacit knowledge can be diffused and used by others. It is done by the conversion of tacit knowledge into metaphors, narratives, analogies, and visuals and through dialogue. The tacit knowledge of customers and experts can be translated through the use of deductive and inductive reasoning and through creative inference. One form of transferring tacit knowledge to explicit knowledge is the creation of expert systems and other explicit tools. This could be used to capture employees' knowledge before they retire from an organisation. These systems and tools begin with tacit knowledge that has been gathered from experts, and which is then formally codified and entered into a knowledge base (Simard, 2000). This is even more necessary within the familiar context of worker shortage, increased employee turnover and the aging of the workforce. Therefore, new information technologies should be used to the fullest extent possible to conserve a company's tacit knowledge.

Combination is the transfer of explicit knowledge to new explicit knowledge. It entails the conversion of explicit knowledge into more complex sets of explicit knowledge through the use of combining data, information and knowledge and dissemination of explicit knowledge. This can be done with presentations and meetings or writing reports and manuals. The combination of explicit knowledge with other explicit knowledge to create more complex explicit knowledge involves teamwork, interdisciplinary

cooperation and new ways of thinking. The use of resources, such as research consortiums, centres of expertise, First Nations groups and environmentalists, should be exploited to the fullest possible extent by the forest products industry. Working together with all industry stakeholders, with their diverse types of explicit knowledge, will create new knowledge. This could help companies ensure sustainability and likewise answer environmental concerns.

Internalisation is the transfer of explicit knowledge to tacit knowledge. It is accomplished with training, exercises and learning by doing. The key is to integrate explicit knowledge into the actions and practises of the organisation and its employees. This transfer of explicit knowledge to tacit knowledge requires strategies that involve people. Learning by doing is, by far, the best method available for this type of transfer. Consequently, the use of exercises and educational tools is invaluable to an organisation.

2.4 Knowledge Management

Knowledge management is about people and the processes they use to gather data, share information, transform knowledge, teach, learn, apply and innovate (Lee and Yang, 2000). Knowledge management can take many forms. It can be viewed as a management function that creates, locates and manages knowledge for long-term benefits (Darroch and McNaughton, 2002). For others, it is a collection of processes that leverages knowledge to fulfill organisational objectives (Lee and Yang, 2000). Another form it takes is that of a business discipline that creates knowledge (Seng *et al.*, 2002). Simard (2003b) provides a useful definition: "developing organizational capacity and processes to capture, preserve, share, and integrate data, information, and knowledge to support organizational goals, learning and adaptation." Consequently, knowledge management is not only about information systems, nor is it simply employee training. Organisations need to find a point of equilibrium between the two approaches.

The benefits derived from good knowledge management are multiple, and include: reduced duplication of efforts, creation of new knowledge, increased efficiency and productivity, and innovation. It also promotes and directs change management. Moreover, it builds and sustains competitive advantages for companies (Nonaka and Noboru, 1988; Nonaka, 1991; Simard, 2000; Darroch and McNaughton, 2002; Peterson, 2002). These benefits are sometimes hard to quantify and are often expressed in unquantifiable terms. For example, good knowledge management practises could improve relationships with industry stakeholders through increased communication. It could also improve customer service, through a better understanding of customer needs.

The technologies that are used for knowledge management include network knowledge infrastructure, knowledge sharing intranets, extranets and external knowledge sharing and groupware technologies and collaboration (Seng *et al.*, 2002). The non-technical means for knowledge management are numerous, and include informal discussions, workshops, exercises, apprenticeships, presentations, etc. (Nonaka and Noboru, 1988). As mentioned above, both technical and non-technical methods are part of knowledge management and one is incomplete without the support of the other.

Keys to knowledge management success are simple, but important. Yuva (2002) explains that the following principles are vital: awareness of the knowledge and skills of others, time and space to create, share and apply knowledge, trust between knowledge seeker and knowledge source, common language and understanding, and recognition mechanisms for those who actively contribute their knowledge to the company.

Effective knowledge management practises will reduce costs and increase levels of customer service. For example, the co-ordination of knowledge and information management in a supply chain can help maximise total profit, increase supply chain optimisation, and reduce the bullwhip effect. The bullwhip effect is the amplification of small changes in consumer demand as these changes move upstream in the supply chain (Lee *et al.,* 1997). This phenomenon results in supply chain inefficiencies and increased costs. Information management and sharing also reduce cycle time and the time needed for new product introduction; in addition, they increase levels of customer satisfaction (Lee *et al.,* 1997; Moyaux *et al.,* 2003). Knowledge management is an important component for all areas of an organisation, from human resources, to R&D, to the supply chain and customer service. These works demonstrate that there are both tangible and intangible benefits to be found, with the implementation of knowledge management structures and practices.

2.5 Dissemination

Dissemination of knowledge is not a simple process. Three areas must be focussed on: teaching, learning and sharing. For the forest products industry, the involvement of all stakeholders is no longer an option, but rather a necessity. For these relationships to be as beneficial and non-confrontational as possible, an increase in education is critical (Innes, 2002). This requires the participation of all stakeholders, including First Nations people, environmentalists, scientists, land owners, and forestry workers.

Teaching can take the form of conferences, workshops, seminars, discussion groups, presentations (virtual or otherwise), discussions, email exchanges, and video-conferencing. The list varies for different situations and different groups of people. Continuous learning by every employee is integral for the future viability of any organisation, as employees and organisations are better equipped to adapt to an ever-changing world (Innes, 2002). Furthermore, learning is an extension of trying (Pfeffer and Sutton, 2000) and comes from both the creation and the sharing of tacit and explicit knowledge (Peterson, 2002). There are several strategies used by companies to enhance learning and teaching. Storytelling, idea banks, time management and accelerated learning workshops (Cook, 1999) are just a few. Some of these strategies may seem inappropriate at first glance, but new realities require new solutions and mental models to turn potential obstacles into opportunities.

There are four main questions associated with the sharing of knowledge. Whom to share it with? What to share? Finally, when and how to share knowledge so that it can be used to create value? The best methods appear to involve the systematic transfer of knowledge. However, this requires an organisational environment or culture that encourages and supports the sharing and transfer of knowledge (Lee and Yang, 2000). It also requires

trust among the parties sharing information and knowledge. This positive culture is seen by some as the key to a successful knowledge management program (Seng *et al.*, 2002). It must be remembered that positive culture is built over time, and that results are realised over the long term rather than the short term.

While information systems can be used to share explicit knowledge, the sharing of tacit knowledge is a social process. This involves close working relationships, whether virtual or otherwise, between people (Lee and Yang, 2000). These types of relationships and the sharing of data, information and knowledge within a company are sometimes complex. Nonetheless, sharing with business partners is even more challenging. Here, many issues come into play. Issues including data ownership, data access, security concerns and conflicting policies between companies (Simard, 2000) complicate and slow down the dissemination process.

2.6 Application

The keys to the application of knowledge and the knowledge value chain in an organisation are strong leadership and the existence of a culture that supports and encourages information sharing, rather than hinders it (Yuva, 2002). An employee knowledge database is an example of a common practise in other industries. With new information technologies, physical space is no longer a necessity. Virtual space, in the forms of intranets, extranets, virtual libraries and discussion forums, is limited only by the imagination. However, for these tools to be effective, a common language must be agreed upon. Furthermore, all parties must agree on key terms and formats. To achieve positive results, it is up to each company and its management to commit to knowledge and the knowledge value chain. Enthusiasm about knowledge is infectious, but it takes a leader to catch the bug.

The appropriate and timely application of information and knowledge to the products, services or operations of an organisation is the goal of any knowledge management system. But, it is only when knowledge is applied that it can give competitive advantage to organisations (Lee and Yang, 2000). Thus, companies need to apply and use the knowledge at its disposal. In this way, organisations will be able to innovate and create sustainable competitive advantages.

2.7 Innovation

There are two types of innovation: incremental and radical. Incremental innovation is the most common type of innovation. It is often derived from listening to, and then answering, the needs of clients. In other words, incremental innovation is often pulled from the market (Darroch and McNaughton, 2002). Radical innovations tend to make certain skills and knowledge redundant, are often the result of new technology and are science based. Centres of expertise (for example universities, research organisations such as FERIC and Forintek in Canada and research consortiums such as FOR@C) can provide the capacity and ability for companies to turn invention into innovation (De la Roche and Dangerfield, 2002). Not surprisingly, it is the role of these centres of

expertise to provide innovative solutions and methods to support the long-term vitality of the forest products industry.

Innovation applies to both products and processes. When new knowledge, technology, and methods are applied to processes, in particular at the supply chain level, significant value can be added for both actor enterprises and the end customer (De la Roche and Dangerfield, 2002). Darroch and McNaughton (2002) explain that all innovations require companies to be flexible and opportunistic. For these authors, a knowledge management system can help companies become more agile. Two examples of recent innovations in the industry are new engineered wood products, and supply chain designs that try to integrate client demand, pulled from the market, into operations.

All types of innovation form the lifelines of companies and are the key to survival (Cavusgil *et al.,* 2003). As De la Roche and Dangerfield (2002) explain, there is a shared government and industry vision of the Canadian forest industry. Both actors desire "an internationally competitive industry based on sustainable forestry achieved through a knowledge centred, innovation based investment." Government organisations and centres of expertise will need to work together to replace the old mentality that floods the markets with non value-added products with one that looks to produce more value-added products and services for consumers.

The knowledge value chain and its effective management should naturally lead to innovation. The efficient management of the knowledge and information that is created within organisations, regardless of the source, (customer feedback, centres of expertise, employees, or other stakeholders) has a strong effect on the development of both radical and incremental innovation.

3 The role of centres of expertise in the knowledge value chain

3.1 Approaches to R&D

The knowledge value chain needs data, information and knowledge to operate and dissemination to continue. The raw material, data, often comes from scientists and practitioners (Simard, 2003b) and their research projects. Companies use this research to develop information and knowledge, to create new products and processes or to improve existing ones. Research and development can be organised using four main approaches. It can be done in-house, with a separate R&D department. It can be outsourced for specific short term projects. Finally, companies can either collaborate with other organisations, to develop innovative processes and products together or collaboratively outsource to a third party. (See Figure 1).

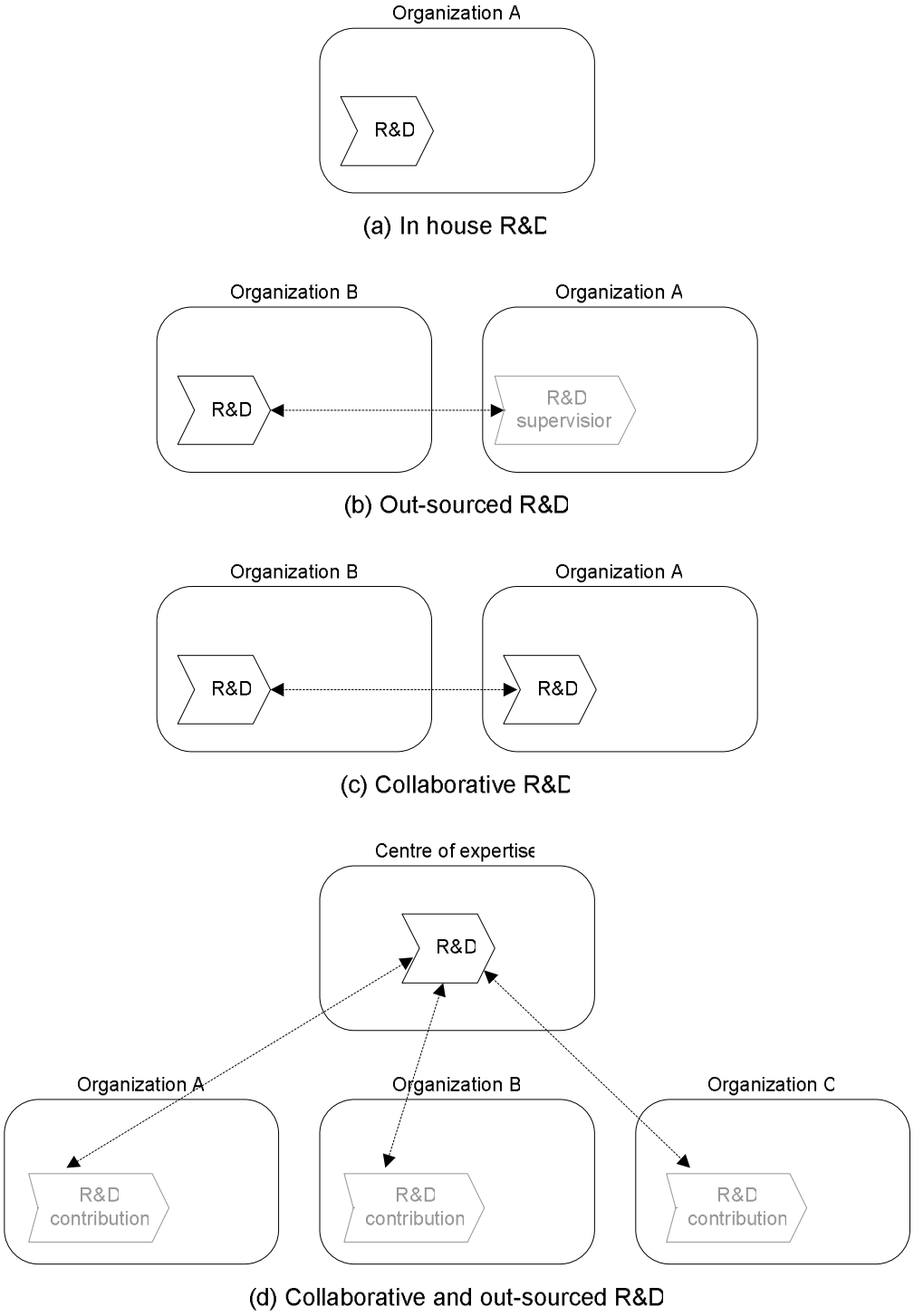

Figure 1: Modes of R&D

In a similar fashion to the knowledge supply network, (Mak and Ramaprasad, 2003) where manufacturing companies concentrate on their core competencies and outsource the rest to specialists, in-house R&D should focus on the core competencies of an

organisation (Narula, 1999). In-house R&D, in this case, is strongly related to the company's competitive advantages and knowledge should not be shared. In contrast, the collaborative approach is especially interesting when the benefits of the research area are unknown or marginal (Narula, 1999). Many authors have also demonstrated that when companies wish to acquire a new technology, or risk losing knowledge, they are more prone to cooperate in collaborative type relationships (Poulin, 1994). Today, most companies use a mix rather than rely on a sole approach.

To react to the pressures of the new knowledge economy, companies are increasingly being forced to search outside of traditional company boundaries for external sources of knowledge and information. They find this knowledge and information from a variety of sources including: centres of expertise, key customers, suppliers and competitors (Chiesa *et al.*, 2000). For example, many forestry companies outsource their business intelligence R&D to organisations such as Paperloop, a news and information provider based in the United States, for information about business exchanges in the global forest products industry.

Collaborative networks of organisations and partnerships are now common in the industry. Pooled resources, knowledge and information circulate the network with speed and at low cost (Chiesa *et al.*, 2000). Collaboration can take many forms including: alliances, consortiums, networking and joint R&D projects. Each form has its own risks and rewards. While all these forms of collaboration have an important place in the forest products industry, this paper looks more specifically at centres of expertise.

3.2 Examples of centres of expertise

The authors define a centre of expertise as a centre, whether virtual or physical, that regroups experts from multiple disciplines to study complex and multidimensional problems in a team environment in order to create new knowledge and insights. The mission of such centers may serve various purposes and "customers/audience". This is largely determined in relationship to funding sources. The following three examples of centres of expertise follow the structure of outsourced and collaborative R&D presented in Figure 1(d).

1. SkogForsk is the research institute for the Swedish forestry sector. They carry out applied research in, among others: the development of technology, environmental and conservation issues, breeding of forest trees, and organisational issues. Funding comes from a mix of public and forest company funds and from contract work and grants.
2. Forintek is Canada's wood products research institute. It is a private and non-profit organisation funded by public monies and member fees. Their role is to: "support the forest products industry in optimizing manufacturing processes, extracting higher value products from the available resource and meeting customer's expectations of performance, durability and affordability." They carry out a variety of research on such topics as: value-added product development, resource assessment and characterisation, market research and much more.

3. IUFRO, the International Union of Forest Research Organizations has as its mission to: "promote the coordination of and the international cooperation in scientific studies embracing the whole field of research related to forests and trees." It is a non-profit, nongovernmental international organisation with 15,000 member scientists and over 700 member organisations worldwide.

3.3 Case study: FOR@C model of a knowledge value chain

The FOR@C Research Consortium in e-Business in the forest products industry is based at the Université Laval in Quebec City, Canada. Its research activities are in the fields of supply chain management and e-Business for the forest products industry in Canada. FOR@C is a centre of expertise that regroups 15 public and private partners. Its objectives reflect its desired role in the knowledge value chain:

1) Improve the competitiveness of forest product companies.
2) Develop skills via graduate student training and continuing education.
3) Develop and disseminate knowledge serving to advance the state of the art.
4) Maintain the involvement and satisfaction of partners.

The role of FOR@C (as a centre of expertise) in the knowledge value chain is outlined in Figure 2. Examples of Consortium activities are described below.

3.3.1 Data

Full time Master's, Doctoral and Postdoctoral students gather and sort data from a variety of sources. These include: consortium partners, on site experiments, other centres of expertise, the literature, practitioners, scientists and surveys.

For example, a survey on the state of e-Business in the forest products industry in the province of Quebec was made during April and May of 2002. More than 320 companies, involved in all aspects of the industry, were questioned on their use of the Internet, Internet technologies and personal computers in their operations and for the management of their supply chains. Surveys of this type are done to become more aware of attitudes and practices prevalent in the industry. It is hoped that, with a better understanding of the current state of the industry, more adequate means and methods to disseminate knowledge can be developed. Furthermore, the information created from the raw data can be used by the industry to benchmark their practises and identify possibilities for improvement.

The creation and treatment of data is the goal of another project. This project deals with the development of an experimental platform that will eventually permit the testing of various configurations of the value chain in the forest products industry, and aid in the establishment of different operational planning approaches for each of the business units of the value chain. The platform will be used as an integration tool for the results of the various research projects to converge in one place. This experimental platform will be made up of intelligent software agents that will collectively manage procurement, production and delivery operations through the use of raw, detailed local information (D'Amours, 2003).

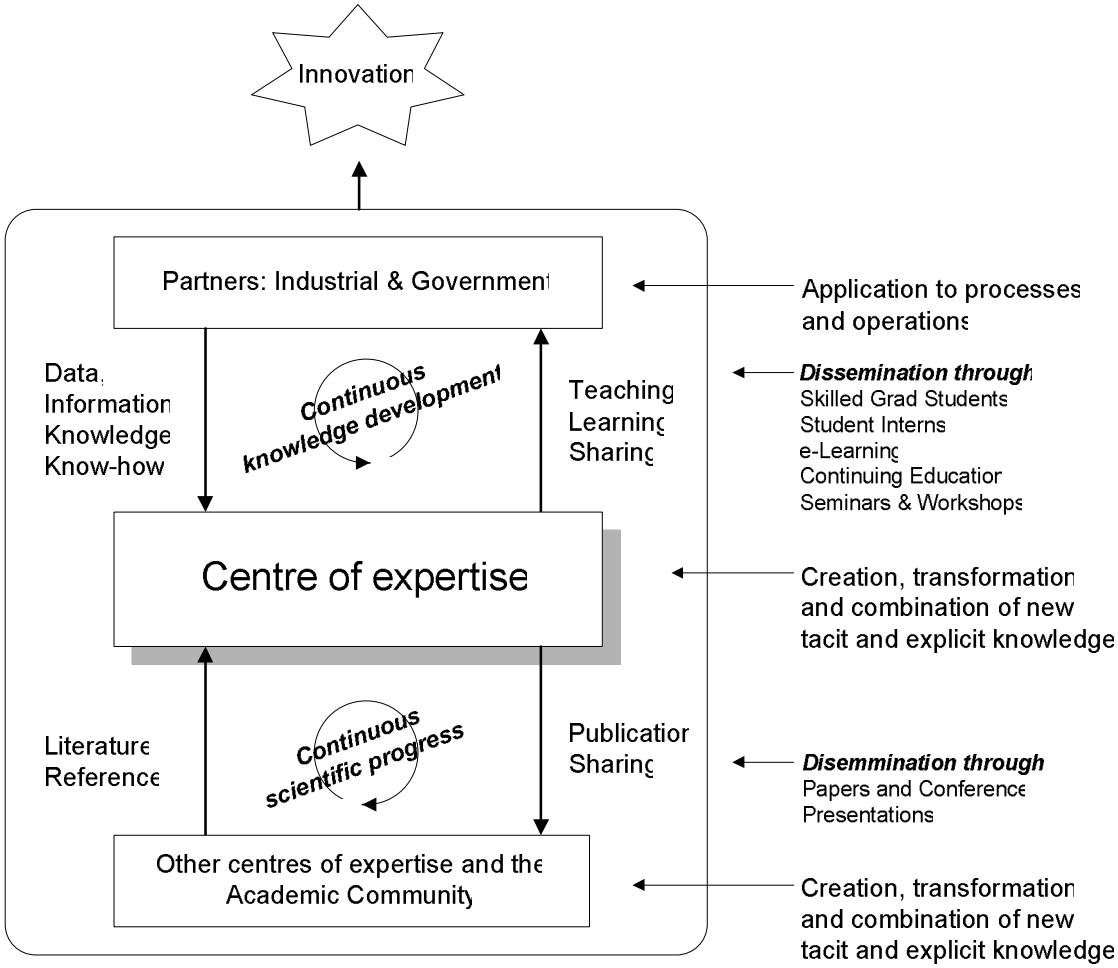

Figure 2: The FOR@C model of a knowledge value chain

3.3.2 Information

To access information within any organisation, it is important to know who knows what, and how to contact the person with the knowledge another needs. To this end, FOR@C provides a secure Extranet on its servers. In this virtual space, students, professors and external members can manage documents related to their projects. The public website lists the students' main research interests, and gives access to public reports and papers they have written and links that others could find useful if they want to find out further information. An Extranet forum is available for Consortium students, professors, employees and external members to send messages and queries to request information about their research interests or projects. The objectives of such forums are to save members' time and the resources of an organisation. However, if success can be measured by the number of messages the forum has not been successful as in the first seven months of operation there were only 55 messages posted. This could be due to the close physical proximity of team members or the use of other means of communication, such as email and instant messaging services.

3.3.3 Knowledge and knowledge transformation

Nonaka and Noboru (1988) explain that knowledge-creating teams and projects play key roles in value creation. Centres of expertise often use multidisciplinary teams to this end. These types of teams also allow a great deal of tacit knowledge to be used, transformed and shared. Projects carried out in collaboration with industrial partners are another effective way for the Consortium to create knowledge. Under the responsibility of research leaders and professors, these projects are aimed at all aspects of business, from strategic planning through tactical decision making to operation and production planning for final delivery to end consumers.

Socialisation

The conversion of one's own tacit knowledge to another person's or an organisation's tacit knowledge is accomplished in various ways. For professors and students, personal exchanges are an obvious method for this exchange. Socialisation also occurs when students work on their projects, on site with their partner company's employees. Here, there is a transfer of the company's tacit operational know-how to the equally tacit theoretical know-how of the students. An experimental platform is being developed through socialisation. A small team of experts in computer programming, artificial intelligence, supply chain management and forestry are working in close collaboration on it, exchanging their ideas and knowledge to create an innovative tool that can be used by others. This may be seen as a "combination' tool, but it is created through the transfer and sharing of tacit knowledge among team members.

Externalisation

The conversion of tacit knowledge to explicit knowledge, so that it can be disseminated and used by others, is a necessity for all organisations. FOR@C has taken this as a challenge, and as such, tries to develop tools to support this conversion. The experimental platform, mentioned previously, is an example of this, but the Consortium also uses the Internet as a medium to create on-line courses to teach practitioners. These courses are developed by experts in the field of e-Business, supply chain management, marketing and resource planning. Courses such as these serve to transform the tacit knowledge of the experts into explicit knowledge that can be widely disseminated.

Combination

The conversion of explicit knowledge into more complex explicit knowledge is perhaps the most obvious output of a research consortium. Professors and students conduct research, then write papers, give presentations and compile reports. The survey on e-Business was just data until the Professors and students studied the results, carried out research about e-Business in other industries, and wrote reports. Now the results are explicit knowledge that can be used by other research organisations such as FERIC, government institutions such as CRIQ (Quebec Centre for Industrial Research) and small and medium sized forest industry companies of Quebec to decide which directions to take, or not to take.

Internalisation

The conversion of explicit knowledge into an organisation's tacit knowledge is another place where FOR@C helps forest companies. Seminars, workshops and on site training are all part of the mandate of the Consortium. The Quebec Wood Supply Game (QWSG) is an exercise that uses learning by doing, which allows employees to understand the dynamics (at least the basics) of a supply chain. Moyaux *et al.* (2003) explain how FOR@C adapted the Wood Supply Game to the Quebec forest sector. The original Wood Supply Game uses the North European forest sector as its framework (Fjeld, 2001) and is an adaptation of the Beer Game. All three games are used to study supply chain dynamics. FOR@C has developed a workshop that it gives onsite to introduce employees to the concept of a value chain. It illustrates the problems (for example the bullwhip effect) that can be encountered and the challenges companies face today to integrate their value chain to become more efficient and cost effective. The explicit knowledge of the supply chain is shared through a game so that it can be understood by people with no background in supply chain management. This new tacit knowledge will hopefully enable participants to make better decisions and better understand the decisions that are made by others.

3.3.4 Dissemination

Centres of expertise not only need to come up with the raw material of the knowledge value chain; they also need to discover the tools and methods necessary to disseminate it. Learning, sharing and teaching are everyday activities for FOR@C. All Consortium members have access to the Extranet, where they can post and access papers, presentations and public reports that could be of interest to members.

As previously stated, an important part of the mission of FOR@C is training and the dissemination of knowledge. The Consortium organises seminars, on-line training and workshops for forest products companies of Quebec. On-line training uses Internet technologies to permit individuals from around the province to learn at their own pace, without the added costs and inconvenience of transportation.

The seminar "Integration of e-Business in the forest product industry" was aimed at small and medium sized companies of the forest products industry in Quebec. The day long seminar, with talks given by experts in the field of e-Business from government perspective, marketing, and industry examples, explained current practises and examples of how new technologies are being integrated into current business practises. A seminar on supply chain management is another example of such dissemination tools.

Tools such as the QWSG and on line training courses are used to disseminate knowledge created by the Consortium to the industry. A lack of participation by industry members seems to suggest that more work is needed to solve this issue. It is possible that the Consortium will need to work on the marketing of these tools, or that the teaching mediums will need to be reanalysed. Another possible solution could be to seek the support of regional institutions, either public or private. These institutions have closer personal ties with members of the industry, which might be necessary. However, this

lack of participation could also indicate that the industry does not see a need for the knowledge provided.

Additionally, a summer school is organised each year along the themes of forestry and e-Business. Internal and external members can attend three-hour lectures on topics ranging from marketing forest products using Internet technologies to introduction to e-Business to collaborative supply chain practices.

3.3.5 Application

The experimental platform has been developed to simulate the reality of the planning and control of the forest products industry supply chain through the application of algorithms developed to different configurations. However, the application of this tool and other tools is largely up to the companies and organisations that work in partnership with the Consortium. Unless companies in the forest products industry adopt and use the tacit and explicit knowledge created and provided by centres of expertise, they will be unable to fully benefit from the research at their disposal.

3.3.6 Innovation

A value added strategy, like the one adopted by many companies in the forest products industry, is market oriented and based on innovation and knowledge (De la Roche and Dangerfield, 2002). Centres of expertise create and disseminate new and innovative products and processes as a direct result of the knowledge value chain. Some examples of innovations are: new business models that integrate internet technologies, new configurations of the value chain, new operations planning and control methods that provide the most efficient use of an organisation's limited resources.

4 Conclusion and further study

The global forest products industry is not unique in facing a rapidly evolving environment. However, the fundamental nature of the industry in the economies of many countries and regions is unique. The health and vitality of the industry into the future is still not assured and companies need to adapt new business methods to ensure long-term profitability.

Knowledge management has been adopted by many industries and companies with great success. The forest products industry can use the tools of knowledge management and the model of the knowledge value chain to turn the challenges of the future into business opportunities. Centres of expertise can play an important role in the knowledge value chain. Data, information and knowledge can be transformed, and then learning can take place through sharing and teaching. The application and use of the generated tacit and explicit knowledge, for innovation and sustained competitive advantage is wholly the responsibility of forest products industry companies and practitioners.

The important role that centres of expertise play in the knowledge value chain should not be overlooked. As the fulcrum between the two loops of continuous scientific progress

and continuous knowledge development, these centres must develop tools and methods so that their findings and research are disseminated and applied to the industry. Diverse tools and methods need to be used for the different audiences served by centres of expertise, i.e. industry and the scientific community. The tools and methods used to disseminate knowledge also depend on the nature of the knowledge and research developed by the centre of expertise. The popularisation of research and findings is a vital part of the role of centres of expertise, and more attention needs to be placed on this aspect. In particular, the background knowledge of the audience needs to be taken into consideration. Therefore, the dissemination of research may require the use of preliminary training and teaching, so that the audience can understand and use the research results to innovate and create value for their organisations.

Informal methods, such as breakfast meetings or learning games that encourage tacit and explicit knowledge exchange and creation can be used to facilitate communication. Not everything attempted will succeed, or prove popular, but it is through trial and error that innovative ideas become reality.

Further empirical study of the validity of the knowledge value chain concept, similar to the empirical study of Nonaka's theories on knowledge creation by Best *et al.* (2003), will be necessary. In addition, the role of centres of expertise in the forest products industry needs to be more fully explored to develop efficient tools and methods for knowledge exchange and transfer.

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