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Current State-of-Knowledge: Innovation Research in the Global Forest Sector

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ABSTRACT

Innovation research within the forest sector has experienced rejuvenation in recent years as global competitiveness of manufacturing industries has become a critical policy issue at national and regional levels. A broad picture of the state-of-knowledge is needed to help identify gaps and future research needs. Accordingly, we provide a synthesis of the literature using a three-part typology: organizational innovativeness, new product development process, and innovation systems. The general literature in each area is briefly explored along with in-depth coverage of literature from the forest sector. Although each research area has been explored in the forest sector literature, the new product development process area is clearly underdeveloped. Very little is understood about how forest sector firms approach new product development or, on the other hand, why many apparently do not proactively develop new products. Future research directions for each research stream are discussed.

Keywords: innovation, innovativeness, innovation system, new product development

Introduction

Innovation has been frequently connected to healthy economic growth, and an organization's ability to innovate is recognized as a key factor affecting its survival and overall success (Schumpeter 1911, Damanpour and Gopalakrishnan 2001, Karathanos et al. 2004, Aghion and Howitt 2005). Countries with fast-developing economies, such as China, have had a profound impact on the competitiveness of the manufacturing sectors in North America and Western Europe. Thus, it is not surprising that dramatic employment losses and poor performance have spurred a renewed interest in innovation among Western economic development specialists, researchers, and industry practitioners. The forest products industry is a prime example of an industrial sector where the call for innovation has strengthened as profit margins have tapered and employment declined.

Forest products manufacturing has long been identified as a mature industry where commodity products and low-cost strategies are emphasized (Cohen and Sinclair 1989, Hansen et al. 2002, Juslin and Hansen 2003). Corporate R & D in the forest sector has declined over time as a result of cost-cutting (Mohr 2002). As a result, it is often suggested that the industry lacks a focus on innovation even

though there are clear examples of innovative companies within the industry. There are a number of factors that may contribute to a lack of innovation and innovativeness. For example, a disconnect often exists between manufacturers and end-users of wood products. This disconnect can interrupt the flow of potential innovative ideas from consumer to manufacturer. Codes and practices in the homebuilding industry (where most wood products are used) may serve as an impediment to innovation by the industry. Although the industry has undergone considerable consolidation in recent years, most sectors are still relatively fragmented when compared to competing industries such as steel or cement[1]. These factors, as well as many others, may restrict innovation in the industry.

(1) The authors would like to thank an anonymous reviewer for these ideas regarding constraints on industry innovativeness.

Between 1999 and 2003, the United States lost nearly 12 percent of its wood furniture manufacturing jobs (USDOC 2005, 2001). In Canada, government statistics show 40,000 jobs lost in the forest sector since 2000 (TTJ 03 September 2005). These values are used as an example to motivate innovation in the European forest industry, in order to maintain competitiveness (Kalela 2004, Roadmap 2010).

Forest sector researchers have recognized the need for studies focusing on innovation and a meaningful body of literature has begun to develop. The topic has been approached from a wide range of academic disciplines. For example, a special innovation issue of *The Forestry Chronicle* was published in 2002, and *Forest Policy and Economics* will publish a special innovation issue in 2006. The forest products industry has traditionally focused on process innovation as a way to maximize recovery from a diverse forest base and to increase product quality (Peters et al. 2006). Consequently, process innovation has seen considerable attention in the forest sector literature (e.g., Lee et al. 1999, West and Sinclair 1992, Cohen and Sinclair 1989). However, it can be argued that the industry often focuses too much energy on operational effectiveness (e.g., Porter 1996), and the drive to remain competitive is forcing companies to look beyond process innovation. Forest sector researchers are now advocating a renewed look at innovation and competitiveness in the industry (Bullard and West 2002, Schuler and Buehlmann 2003, Buehlmann et al. 2003).

Given the heightened interest in innovation in the forest sector and apparent growth in research activity, it is important for researchers in the field to have a comprehensive view of development within the field and to recognize the breadth of work taking place globally. In the discussion that follows, we build on earlier work by Kubeczko and Rametsteiner (2002) to *synthesize recent works on innovation specific to the forest sector, and to link them to general streams of innovation literature in an effort to provide a broad view of the state-of-the-knowledge in the field*. We conclude by outlining important future research directions that we believe will develop the theoretical base and understanding of innovation and innovativeness in the forest sector.

The Concept of Innovation

Innovation Definitions

The etymology of the word 'innovation' refers to successful introduction of novelties. Thus, in its most holistic sense, innovation can be defined as the "generation, acceptance, and implementation of new ideas, processes, products or services" (Thompson 1967) or as "a discontinuously occurring implementation of new combinations of the means of production" (Schumpeter 1911). Specific conceptualizations and operationalizations of innovation have been very inconsistent (Garcia and Calantone 2002). We briefly outline the conceptual difficulties by discussing the following issues:

- the difference between innovation and innovativeness,
- the difference between innovation and invention, and
- the difference between innovation as a process and innovation as a discrete event.

Innovation and innovativeness can be viewed as distinct from one another or used interchangeably (Damanpour 1991). If no distinction is being made, innovation (innovativeness) can be defined as an adoption of a behavior or idea, in which adoption of an innovation encompasses the creation or use of the new behavior or idea (Damanpour 1996). Other researchers more distinctly separate the concepts of adoption and creation. Innovativeness can be seen as comprising the propensity to create as well as the propensity to adopt (Knowles 2006). If innovation and innovativeness are treated separately, innovativeness can be defined as an organization's overall innovative ability (Wang and Ahmed 2004) and embodies some kind of a measurement contingent on an organization's proclivity toward innovation (Salavou 2004). In other words, organizational innovativeness is an enduring organizational trait that is consistently manifested in three dimensions: mean number of innovations over time, mean time of innovation adoption, and consistency of time in innovation adoption (Salavou 2004).

Innovation and invention are often used synonymously. In that context, both terms refer to creative processes incorporating the application of existing ideas to create a unique solution to a problem (Cooper 1998). If a distinction is being made, innovation brings something into new use and suggests commercialization, whereas inventions bring something new into being (Hoskisson and Busenitz 2002). The inventor organization thus seeks to develop new processes or outputs as ends themselves, perhaps choosing to refrain from commercial use of the invention for long periods (Cooper 1998).

Process models advocate the view that innovation consists of different phases. They include, for example, idea generation, research design and development, prototype production, manufacturing, marketing and sales (McFadzean et al. 2005), identifying problems, evaluating alternatives, arriving at a decision, and putting innovation into use (Rogers 2003). From a process perspective, the main concern is to identify the phase of adoption or implementation that ultimately decides the success or failure of the innovation itself (Cooper 1998). Issues of interest are, for example, the role of communication and the characteristics of individuals and teams in facilitating successful innovation. Advocates of innovation as a discrete event do not ignore the processes involved in innovation, but they tend to focus on the differentiation between innovators and non-innovators that occurs when the

innovation is put to use (adopted) within the organization (Cooper 1998). The event approach assesses the merits of particular organizational structures or strategies in the adoption of innovation. Thus, studies often take a more macro approach, and the research questions often deal with typing the firms that are more prone to the adoption of innovation.

Dimensions of Innovation

Regardless of a concrete definition, researchers and practitioners agree that innovation comes in many forms and consists of multiple dimensions. Various authors have advocated a distinction between technical and administrative (Han et al. 1998), product, process, and organizational (Boer and During 2001), and product, process, and business systems dimensions of innovation (Hovgaard and Hansen 2004). Innovation is also multi-dimensional according to the definition provided by the Oslo Manual (2005), "*An **innovation** is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organisation or external relations.*" Cooper (1998) suggests that the innovation concept consists of three main dimensions, and each dimension incorporates a continuum ranging from:

- product to process
- administrative to technological
- incremental to radical.

Product innovation reflects change in the end product or service offered by the organization, while process innovation introduces changes in the way firms produce end products or services (Utterback 1994). Administrative innovation includes changes that affect the policies, allocation of resources, and other factors associated with the social structure of the organization, while technological innovation incorporates the adoption of an idea that directly influences the basic output processes (Daft 1978). Nelson and Winter (1977) define technological innovation as a non-trivial change in products and processes where there are no previous experiences.

The third way of dimensionaliszing innovation is along a continuum from radical to incremental. It is a frequently used distinction, but it has been shown to be problematic to apply. Incremental (sustaining) innovation occurs within the boundaries of established policies and customary views, and results in competence-enhancing measures that often are oriented to developing new processes rather than new products or services (Ireland et al. 2003). Radical (disruptive) innovation signifies or leads to elemental changes in organizational routines and approaches to products, processes, and markets (Simsek et al. 2003, Elfring and Hulsink 2003). In their study of technological innovations, Dewar and Dutton (1986) define radical innovations as fundamental changes that represent revolutionary transitions in technology, whereas incremental innovations are minor technological improvements or simple adjustments. In a similar approach, Moore (2004) outlines seven types of innovation ranging from disruptive to experiential.

The radicalness of innovation depends upon the perceptions of those familiar with the degree of departure of the innovation from the state prior to its introduction. Thus, defining an innovation

requires a baseline, and it is relevant to ask to whom the innovation is new. For example, managers may differ in their opinions of an innovation depending on their familiarity and experience (Dewar and Dutton 1986). Kotabe and Swan (1995) suggest that innovation can be defined in terms of newness to the company (industry) and newness to the market. Perceived newness of the offering from a market perspective is an essential part of value creation and, thus, it is commonplace for both marketing related innovation literature (Hauser et al. 2005) and industry practitioners to focus on product innovations.

The Conceptual Approach Used in this Paper

As our purpose is to assess a variety of literature streams, we have adopted a broad view of innovation that captures its inherent multidimensionality. Although innovations do not necessarily have to be commercialized or fully implemented, we assume that they nevertheless are intended to contribute to the success of the company. We incorporate both adoption and creation into our definition, and accept both a process approach and discrete event perspective. Thus,

> **Innovation is creation and/or adoption of new ideas, processes, products, or services that are intended to increase value to the customer and contribute to the performance or effectiveness of the firm.**

Theoretical Approaches to the Study of Innovation

Following the variety of innovation definitions, a number of typologies of innovation research have been proposed as well. The concept of innovation is often tied to the process of an individual or organization adopting a new idea, object, or practice (Rogers 2003). Accordingly, much of what is recognized as innovation research focuses on the propensity to adopt and introduce an innovation. Any adoption is, in effect, a re-creation at the organizational level. Acknowledging that the propensity to re-create is an important characteristic of an innovative organization, Rogers (2003) outlines eight major types of innovation research:

1. earliness of knowing about innovations
2. rate of adoption of different innovations in a social system
3. innovativeness
4. opinion leadership
5. diffusion networks
6. rates of adoption in different social systems
7. communication channel usage
8. consequences of innovation

Wolfe (1994) identified three streams of research on organizational innovation: diffusion of innovation, organizational innovativeness, and process theory models. The primary overlap between

the abovementioned typologies is the concept of organizational innovativeness. In the organizational innovation research approach, the focus is on the determinants of innovativeness at the organizational level, and the interaction between individuals and organizations.

Salavou (2004) suggests that, although product innovativeness is part of the organizational innovativeness phenomenon, it is more specific and indicative of firms involved in product-related innovative activity. She advocates for a shift from organizational to product innovativeness, and indeed, the new product development (NPD) process has seen extensive consideration in the literature on innovation. Compared to the organizational-innovativeness approach described above, the relative emphasis of the NPD approach is more focused on the actual output of the innovation process, describing the process of developing and or improving new products and improving it, and ensuring the successful commercialization of the innovation. Accordingly, it fits well with the categories of innovation research found in the marketing literature (Hauser et al. 2005): product development, organizations and innovation, market entry and defense strategies, and consumer response to innovation. The systemic approaches to innovation research, in turn, view innovation as a socially embedded phenomenon, with the firm at the center (Edquist and Johnson 1997) focusing on the interaction among actors and institutions, and how this impacts successful innovations. Referred to as "innovation systems" research, many see this approach as superior since it embraces the complexity of innovation processes.

Using the theoretical approaches listed above as context and background, we have chosen to cover the literature across three research streams, namely *organizational innovativeness* (including adoption and diffusion research), *new product development*, and *innovation systems* (**Table 1**). We recognize that the collective boundaries of these research streams do not comprehensively incorporate all aspects of innovation research and there is undoubtedly overlap, but we feel this approach allows the best coverage for forest sector innovation work, while at the same time, sufficiently narrowing the focus to assure meaningful coverage and a feasible synthesis of the literature. We have specifically chosen to exclude from consideration in the context of this work, innovation at the individual level, though we briefly consider characteristics of managers and impact on firm innovativeness. Similarly, we limit the scope of the paper to innovations by enterprises, including the wider context within which enterprises operate (the "innovation system") as it is a major focus among European researchers. We thus do not cover institutional innovation, innovation from a micro- or macro-economic point of view, or policy aspects connected to innovation.

Table 1. Three innovation research streams considered in the study.

Research stream	Basic question(s)	The main level of analysis
Organizational innovativeness	What are the determinants of innovativeness within organizations?	Organizational
New product development	How can a successful new product best be developed?	
Innovation systems	What mix of actors and institutions best facilitates innovation? What are the interactions between actors and institutions, and how does this impact successful innovation?	System

Organizational Level Research

Organizational Innovation

Of interest in this research stream is identifying what influences an organization's propensity to create and adopt innovations and its effects on company success or profitability (Wolfe 1994). The focus lies on the firm and inter-firm relations, and the basic research question is *what are the organizational properties that enhance or hinder the firm's ability to innovate* (Kubeczko and Rametsteiner 2002, Damanpour 1991). Innovation is conceived as a means of changing the organization, either as a response to changes in the external environment or as a preemptive action (Damanpour 1996).

Researchers have identified an extensive list of aspects influencing innovation at the organizational level. Examples of these reviews include Hurley and Hult (1998), Brown and Eisenhardt (1995), Rogers (2003), Thwaites and Edgett (1991), and Damanpour (1991). Notable theoretical sources are structural functionalism and contingency theory (i.e., how organizational structure constrains or facilitates innovation and the relationship between the organization and the environment) (Johannessen et al. 2001). Recognizing that research in this area is extensive and empirical findings are partly conflicting, we identified those factors that are consistently associated with innovation, and classify them under two broader categories following Rogers (2003):

(i) individual (leader) characteristics:

- managerial support and tenure
- specialization and professionalism

(ii) internal characteristics of organization

- organizational design and culture
- company size, slack resources and industry maturity

We first clarify and illustrate the effect of these factors on innovation by referring to recent general empirical studies. We then introduce and summarize organizational innovation studies specifically conducted within the forest sector.

Individual (Leader) Characteristics Determining Innovation. — Many studies argue that the role of managers and management teams in organizational innovation is considerable and warrants further research (Dess et al. 2003, Guth and Ginsberg 1990). Burgelman (1983) noted that middle-manager effectiveness at building coalitions among peers and higher-level managers in support of their creative ideas affects the degree of success when implementing an innovation. On the other hand, organizations that publicly embarrass employee mistakes condition them toward incremental innovation (Baker and Sinkula 2002). Bantel and Jackson (1989) suggest that more innovative banks are managed by more highly educated teams with diverse expertise. A higher proportion of managerial support and managerial tenure facilitate successful adoption of innovations (Kimberly and Evanisko 1981), and positive manager attitudes toward change creates a favorable innovation climate.

Specialization and professionalism are considered to have a positive effect on innovation. A variety of specialists provide a broader knowledge base, increase boundary-spanning activity, and a commitment to moving beyond routines (Damanpour 1991). However, from an organizational-learning perspective, the effect is more complex. The benefit of knowledge integration within an organization comes from capturing the specialized knowledge of different individuals (Grant 1996). If two people have similar knowledge, there is no gain from integration while if they have entirely separate knowledge bases (i.e., they are highly specialized) integration is inefficient or cannot occur.

Internal Characteristics of an Organization Determining Innovation. — Organizational structure and culture affect innovativeness mainly via information and knowledge exchange. External and internal communication play a central role in innovation research as they connect innovation studies to organizational learning and knowledge management. Damanpour (1991) concludes that exposure to ideas from the external environment, an improved communication climate, and firm-internal cross-fertilization of ideas establishes a positive relationship between communication and innovativeness of which formalization, centralization, and complexity are the most commonly studied structural aspects. Formalization is the extent to which documented standards are used to coordinate and control social actor behavior and outputs (Bodewes 2002). Formalization improves standardized and predictable behavior, routinizes actions, and increases information control within organizations (Low and Mohr 2001), which in turn leads into better coordination, reduced role ambiguity and conflict, and increased efficiency (Adler and Borys 1996, Robbins 1990). At the same time, it discourages information responsiveness and openness (Damanpour 1991).

Centralization refers to the organizational level of decision-making and the degree of employee participation. Centralization decreases information responsiveness and utilization, employee motivation, entrepreneurial behavior, and awareness of strategic goals (Damanpour 1991). On the other hand, it improves discipline, standardization, single-mindedness, and effective control (Caruana et al. 1998), which enable the company to execute decisions quickly (Englehardt and Simmons 2002).

Complexity is reflected in both the number of multiple hierarchical levels and restrictive channels of communication (Caruana et al. 1998). When employees are removed from organizational planning, control processes, and there is less direct communication, people are less willing or able to internalize and implement corporate goals and strategies (Floyd and Wooldridge 1992). In sum, high degrees of centralization and formalization contribute to knowledge transfer and integration, but hinder finding new knowledge. Thus, although they may impede creation of innovation, they should facilitate adoption and implementation of innovations. Decreased complexity improves knowledge transfer and integration and should improve adoption of innovations.

Contemporary research on market orientation views it as a cultural, rather than behavioral, phenomenon (Homburg and Pflesser 2000). Market orientation is the organization-wide generation of market intelligence that pertains to current and future customer needs, dissemination of intelligence across departments, and organization-wide responsiveness (Kohli and Jaworski 1990). Market-oriented firms are better at adapting to environmental change, which in turn results in organizational change through incremental innovation (Baker and Sinkula 2002). However, as Dickson (1996) noted, market orientation must be complemented by a learning orientation in order to result in optimal innovativeness (i.e., a company capable of radical and incremental innovations). Thus, only companies

that are proactively questioning their existing practices and beliefs maximize their organizational performance through innovation (e.g., Ireland et al. 2003, Hitt et al. 2002).

The size of a company influences its ability to innovate (Hurley and Hult 1998). Ahuja and Lampert (2001) identify three tendencies that generally inhibit radical innovation in large established companies: a tendency to favor the familiar over the unfamiliar, a tendency to prefer mature over the nascent, and a tendency to search for solutions that are near existing solutions. While larger organizations have the necessary resources for creating radical innovation, those same organizations tend to be the most bureaucratic, resistant to change, and even risk averse. Among other things, this has resulted in conflicting findings regarding firm size and innovation.

The role of slack resources in innovativeness was identified in the 1960s (Rosner 1968). Slack resources allow an organization to afford risk taking, maintain an extensive communication network, absorb failure, and explore ideas in a proactive manner, thus having a positive effect on innovativeness. However, Nohria and Gulati (1996) point out that there is an inverse U-shape relationship between slack resources and innovation in organizations, as too much slack diminishes discipline over innovative projects.

Industrial organization theory suggests that innovation differs across the industry life cycle. Utterback (1994) developed a theory outlining how innovation is higher during early stages of the life cycle and declines as industries mature. In addition, he suggested that product innovation is generally higher in early stages while process innovation grows in importance during later stages. However, McGahan and Silverman (2001) found no support for the assertion that innovative activity is lower in mature versus emerging industries.

Organizational Innovation Research in the Forest Sector. — In forest sector research, there are no studies on organizational innovation focusing exclusively on the individual characteristics and role of managers. A few studies have included limited personnel characteristics as part of a larger investigation. As an example, West and Sinclair (1991) found that household furniture producers employing engineers were more likely to adopt new processing techniques. Consistent with theory, professionalism of engineers increases boundary-spanning activity and greater company technical knowledge resources facilitate understanding of technical ideas. Shook (1997) found that the intensity of management (proportion of management positions relative to all employees in the firm) had a negative influence on the adoption of engineered wood products in the homebuilding industry. In their study of factors influencing the success of forest products innovations in Australia and New Zealand, Bull and Ferguson (2006) found that flexible management, firm-wide support, and presence of an innovation champion consistently and positively impacted the outcome of the innovation.

Studies incorporating internal organizational characteristics determining innovation are more numerous, although structural variables are generally not considered. Market orientation strongly influenced the adoption of process technology in western Canadian sawmills (Lee et al. 1999) and has been found to be positively correlated with innovativeness (Crespell et al. 2006). Cohen and Sinclair (1990) found that firm size had a minimal impact on the ability to adopt innovative technologies, and Cao and Hansen (2006) found larger Chinese firms to be more innovative in the area of business systems. Other research has shown that large companies outrun smaller companies in process

innovation, but the difference is not as notable when considering product and business systems innovation (Wagner and Hansen 2005), a topic of considerable interest in an ever increasingly consolidated forest sector.

Fell et al. (2002) found larger homebuilding firms to be more innovative than their smaller counterparts. The importance of slack resources in enhancing innovation has been shown in the Canadian forest sector where companies claimed an inability to devote staff to projects on an on-going basis because of production requirements (Schaan et al. 2001). This too is especially relevant for the forest sector given its tendency to pursue a low-cost competitive strategy (Niemelä 1993, Rich 1986). Hansen (2006a) tested the life-cycle theory of innovation using data from structural panel manufacturers in North America and received mixed results. As expected, plywood mills were found to have a more specialized product line than oriented strandboard mills. Contrary to theory, however, oriented strandboard mills were found to be more product innovative. Välimäki et al. (2004) found that more innovative Finnish companies tended to be more profitable and more internationally oriented. Innovative Chinese furniture firms were less likely be export-intensive, and no connection was found between innovativeness and profitability (Cao and Hansen 2006). A recent study in Spain found no connection between R&D expenditures and firm efficiencies (Diaz-Balteiro et al. 2006). As with the general innovation literature, findings from the forest sector are often conflicting.

New Product Development (NPD) Process

Results from this research stream continue to show that companies are not particularly effective at bringing new products to market, and most new products fail in the marketplace. This has resulted in suggestions that approaches to NPD and supporting market research must be radically rethought (e.g., Wind and Mahajan 1997). The recent literature on NPD has focused on both describing the NPD process and identifying its weakest links.

Hauser et al. (2005) provide a broad and contemporary view of the NPD field and classify research topics on product development processes into the following categories: the fuzzy front end, design tools, testing and evaluation, and product portfolio management. The fuzzy front end is the period when an opportunity is first considered and judged ready for development (Kim and Wilemon 2002), its importance for the NPD process has been increasingly recognized (e.g., Jongbae and Wilemon 2002). Brown and Eisenhardt (1995) present a three-part typology for product development research: rational plan, communication web, and disciplined problem solving. Each of these three research streams analyzes how structures, processes, and actors impact performance. Rational plan research focuses on financial performance of the product, communication web research on the impact of communication on project performance, and disciplined problem solving on the effects of various actors on the development process itself. Urban and Hauser (1993) and Crawford and DiBenedetto (2003) have provided a comprehensive overview of NPD processes.

The contemporary NPD literature has strongly advocated for more structured NPD systems. As an example of this thinking, Belliveau et al. (2002) give in-depth insight into 16 cutting edge NPD tools. Cooper (2000) has outlined ten critical success factors for successful NPD such as top management support, effective incorporation of the voice of the customer, and clear definition of the product before development begins. Important recent benchmarking of NPD practices compared best and worst

performers (e.g., Cooper et al. 2004). The four primary recommendations resulting from the benchmarking work are:

1. create a product innovation strategy tied to overall business objectives,
2. focus on people by creating the right climate, culture, and assembling cross-functional project teams,
3. implement a systematic NPD process, and
4. invest the necessary resources using a portfolio management system.

Another important topic within contemporary NPD research is the role of users. Users, especially lead users, conduct extensive product development for their own use that typically is not captured by manufacturers. Von Hippel (2005) argues strongly that NPD will increasingly incorporate this aspect of the voice of the customer.

NPD Process in the Forest Sector. — Very little NPD research exists that is specific to the forest sector. This situation may be partially explained by a phenomenon outlined by Wind and Mahajan (1988): where NPD had become quite sophisticated, it simply was not employed by many firms and those employing a NPD process were doing so ineffectively. Unfortunately, the present-day forest industry likely fits this description. Hansen (2006b) documented aspects of NPD practices implemented by North American forest industry companies. Responding companies generally have an unstructured approach to NPD and take advantage of few NPD tools. Companies in the study were especially weak in the marketing aspects of NPD, but were relatively strong with respect to financial analysis. On a more positive note, Crespell et al. (2006) concluded that innovative North American sawmills used a more structured NPD process to successfully introduce new products, an indication that use of a NPD process will yield positive results even for commodity-centric firms.

The furniture industry has been the focus of several NPD studies. Calantone et al. (1995) attempted to link innovative activities and business performance in the furniture industry. Their study evaluated the impact of eight product development activities (e.g., design innovation and product development cycle time) and found that each significantly contributed to return on investment and return on investment growth. They also found that when compared to competitors, top performers placed a high strategic emphasis on each activity. Bumgardner et al. (2000, 2001) investigated opportunities for using character marked raw materials in furniture. One component of this research was the development of a 14-stage product development model describing the NPD process of large furniture companies. The model was very similar to that presented previously by Bennington (2002). Contrary to evidence from other sectors of the industry, Bumgardner et al.'s (2001) findings suggest a relatively systematic approach to NPD by large furniture companies.

Bull and Ferguson (2006) used a qualitative approach to evaluate the commercialization success of various new wood products in Oceania. They found that private sector efforts were more successful than those led by government and that product innovations based on a "resource push" were not as successful as those based on "market pull." They also found that a company culture supportive of collective learning and an understanding of the marketplace are important core competencies.

Resource push has often been a motivating factor for product innovation in the forest sector, but these results point to the need for a market focus regardless of the motivation for an innovation.

Extensive work in Sweden resulted in a framework for developing an integrated product development strategy (Nyström 1985). A portion of the research was conducted using the pulp and paper industry. The research evaluated marketing and technology strategies of the companies with respect to their relative "openness" or external orientation. Nyström's (1985) work was based on four case companies and provided no generalizable results. A main finding was that an open marketing strategy resulted in product uniqueness.

Adoption and Diffusion of Innovations

In the area of adoption and diffusion of innovations, studies fall under two broad categories: namely, studies concentrating on the diffusion of products and process technologies over time and studies examining the factors that affect innovation adoption. As previously mentioned, adoption focused research operates from the assumption that innovative organizations adopt innovations (Subramanian 1996). Accordingly, innovativeness is about adoption, time of adoption, and implementation of innovations. This research area has a long history with hundreds of studies originating in a number of disciplines and among many industry sectors.

Innovativeness, according to Rogers (2003), is the extent to which an organization is comparatively earlier in adopting new innovations than other organizations within a system. In particular, the time of adoption of an innovation plays a crucial role in defining the relative innovativeness of an organization. Rogers' adopter category typology has been widely used by innovation researchers; this typology delineates five adopter categories of innovativeness using a normal curve and defining the adopter categories in terms of their standard deviation positions from the mean time of acceptance of an innovation for the entire market. These categories are broadly defined as follows:

- Innovators – approximately 2.5 percent of innovation adopters who tend to be venturesome risk-takers and active seekers of information
- Early Adopters – approximately 13.5 percent of innovation adopters who tend to be more integrated in the social system and are respected as change agents and opinion leaders
- Early Majority – approximately 34.0 percent of innovation adopters who make deliberate adoption choices, but are not considered change agents or opinion leaders in their social system; early majority adopters are believed to provide the critical interpersonal network linkage within the social system
- Late Majority – approximately 34.0 percent of innovation adopters who adopt innovations after the average member of the social system; late majority adopters tend to be cautious and somewhat risk averse in their adoption of innovations
- Laggards – approximately 16 percent of innovation adopters who are the last to adopt innovations in the social system; laggards tend to be traditionalists that resist innovations often due to limited resources; note that laggards are not non-adopters

It should be noted that extensive research has been carried out to substantiate Rogers' adopter category typology (e.g., Mahajan and Peterson 1985, Peterson 1973, Tanny and Derzko 1988). Despite some contextual deficiencies, research has found that Rogers' typology is rather robust in categorizing homogeneous and relatively mutually exclusive adopter classes that can be compared and contrasted with one another (e.g., Martínez and Polo 1996).

While adopter categories provide a measure of the relative innovativeness of an organization based on when they adopted an innovation, the diffusion of an innovation provides a relative measure of the rate at which innovations are adopted within a social system over time. Thus, adoption and diffusion are highly interconnected, with time playing a crucial role in assessing both the acceptance of an innovation, and the factors that affect its acceptance, as well as the relative level of innovativeness of the social system to accept an innovation over a particular time horizon.

Adoption and Diffusion of Innovations in the Forest Sector. — Considerable research has been conducted to assess the factors that both positively and negatively affect the adoption of innovations within the forest sector. For example, Håkanson (1974) examines factors that affect the adoption of special papermaking presses among firms located in several industrialized countries, finding that several factors influencing adoption are country-specific. Most notably, the adoption of a new technology within one country tended to lead to the adoption of that technology by firms country-wide; the same technology would often take several years before being adopted by firms located within other countries. Note, however, that the increased level of globalization and efficiency of information dissemination today relative to 1974 may make these country-specific results less relevant from both a theoretical and applied context.

Similar research identifying factors affecting innovation adoption among organizations within the forest sector includes research carried out by Cooper (1995), Cumbo et al. (2001), Leefers (1981), West and Sinclair (1991, 1992), and Smith et al. (2004). A unifying theme of these particular research endeavors is that while they generally subscribe to Rogers' typology of adopter categories and measure innovation adoption as a dichotomous function, they do not incorporate a time element within their analyses. Thus, distinctions between the levels or degrees of innovativeness among actors within the social system (e.g., early adopters vs. late majority) are not assessed in these studies. Rather, the focus of these studies is on the identification of characteristics (e.g., firm size, technological expertise and progressiveness, opinion leadership) of innovators and early adopters at the firm level.

Using a different research method, Cohen (1989) and Cohen and Sinclair (1990) studied factors affecting the adoption of manufacturing technologies in the North American softwood lumber and structural panel industries by utilizing cluster analysis to group firms exhibiting similar innovation adoption behaviors. Their studies found that innovation adoption within the softwood lumber and structural panel manufacturing industries can be partially explained by relative firm size, investment intensity, and change in relative market shares.

In a study examining the impact of investment in softwood lumber manufacturer innovation development and adoption in Canada, Schuler et al. (1991) develop a model with two competitors (U.S. and Canada) supplying only the North American market. They make comparative forecasts of the consequences resulting from three technology investment strategies: investment at present levels,

increased investments in processing R&D, and increased investment in product R&D. Their simulation results indicated that Canadian lumber manufacturers should concentrate on a mixed strategy that incorporates R&D in product and process innovations in order to maintain profitability and market share against U.S. competitors.

West and Sinclair (1991, 1992) implement Rogers' adoption typology to examine innovation adoption among wood household furniture manufacturers. The researchers develop a specific scale measure of innovativeness, and test several factors thought to promote or inhibit innovation adoption. For example, larger firms were found to be more innovative than smaller firms; innovative firms use more information sources than later adopters; and innovators were more often contacted by others regarding new processes or innovations (i.e., they were seen as opinion leaders). Cooper (1995) builds upon this research by identifying certain elements of organization structure and specific organizational pressures which significantly affect the adoption of manufacturing process innovations in the wood household furniture industry. One organizational construct assessed by Cooper was mimetic isomorphism, often referred to as the organizational "bandwagon effect," which suggests that, when firms face similar competitive environments and constraints, they are forced to behave identically when making innovation adoption decisions. Cooper's results revealed that in the case of wood furniture manufacturers, mimetic isomorphism plays a critical role in the innovation adoption process of late adopters.

Diffusion of innovation research in the forest sector has focused nearly exclusively on mathematically modeling the diffusion paths of innovative products and processes. Early research by Carter and Williams (1957) and later research by Hull (1986), however, use the case study approach to examine factors that affect the speed at which technologies are adopted by pulp and paper manufacturers. One particular objective of these studies is to identify controllable factors that provide the greatest "traction" for new process innovations within pulp and paper so as to increase firm competitiveness by lowering costs and increasing product quality. Collectively, these case studies identify the impacts that systematic internal and external R&D have in promoting the rapid adoption of process innovations; firms without formalized R&D processes were found to be late adopters of process innovations.

Research concerning mathematical modeling of diffusion of innovations in the forest sector is widely published and covers all forest sectors (e.g., Buongiorno and Oliveira 1977; Globerman 1976; Martin et al. 1979; Montrey 1982; Montrey and Utterback 1990; Shook 1999; Speece and MacLachlan 1992, 1995; Steir 1983). The bulk of this research uses product growth models (e.g., Bass 1969) which incorporate past sales data of innovations to estimate the future path of sales. Using similar product growth models, Speece and MacLachlan (1992, 1995), examining fluid milk containers and Shook (1999) exploring the structural wood panels market, investigated how older generations of products affect the adoption rate of new innovative substitutes (i.e., incremental innovations). Their research illustrates that the speed of diffusion for new innovations proceeds more rapidly with each successive generation of innovations. However, their research does not explicitly deal with factors that affect the speed at which innovations are adopted over time.

Innovation Systems Level Research

During the last decade, there has been a proliferation of studies on the systemic features of innovation, much of which has centered around the concept of "innovation systems" (IS) (Freeman 1987, Lundvall 1992, Nelson 1993, Edquist 2001). Much of the IS research is designed to better understand innovation processes and, subsequently, support of national and regional policy development. Innovation systems research incorporates consideration of the many actors that impact innovation in a given region or industrial sector. Through a better understanding of the many actors involved, their interactions, and the institutional frameworks within which they operate to bring about innovation (or not), policy makers can better facilitate innovation and improve industrial competitiveness. The overall function of an innovation system is to produce innovations new to the market, diffuse these innovations, and use them (Edquist 2001). Proponents of systems approaches see an IS approach as being considerably more appropriate to study complex innovation processes than linear concepts that were at the core of innovation research in the 1970s. This type of systems research has produced a huge body of literature, but is still considered a conceptual framework rather than a formal theory (Edquist 2001). The approach has been quite successful in describing the emergence of innovations, actors and institutions, interactions, and effects. The interaction between actors and institutional settings are seen as particularly important for innovation activities.

The IS approach has been highly influential in reviewing and revising innovation policies and strategies on national levels, especially among OECD countries (OECD 2002). Although systemic approaches to innovation research underline the need to focus on innovation as a socially embedded phenomenon that should stretch across all economic sectors, it has mostly been applied in policy practice in "high-tech" fields, often with a technological focus or bias (von Tunzelmann and Acha 2004). More recently, the U.S. Council on Competitiveness (Wessner 2004) and Japanese institutions (Watanabe and Fukuda 2006) have started to promote national policies based on a somewhat modified concept, the "innovation ecosystem", which, in their view, better expresses the systemic and evolutionary nature of innovations.

System analysis focuses particularly on system functional performance and system failures. A number of authors have proposed different classes of system functions (see Hekkert et al. 2005) and system failures, with varying numbers of functions. In one of the first classifications, Edquist and Johnson (1997) summarize the functions of institutions in the process of innovation into three categories:

1. reduction of uncertainties by providing information,
2. management of conflicts and co-operation, and
3. the provision of pecuniary and non-pecuniary incentives.

The institutional system provides knowledge for the enterprise to reduce uncertainties in the economic activities of the enterprise. Institutions (e.g., patent laws, norms for repayment periods, etc.) may reduce uncertainty, either by providing information about the behavior of other people or by reducing the amount of information needed. The institutional system manages the competition and cooperation among individuals and groups necessary for an innovation-friendly environment (e.g., by

supporting networks and clusters). The institutional system also provides a system of non-pecuniary incentives to engage in learning and to participate in innovation processes that can make innovation profitable in the long run. Finally, pecuniary incentives, such as tax rules, government subsidies, and the allocation of resources to universities, channel resources to innovation activities and help to re-channel resources from those activities that are unprofitable.

There are many different approaches to analyzing innovation systems. Two approaches are of relevance with respect to the issue of innovations related to forestry. Innovations in this sector concern the production of wood- and non-wood products as well as territory-bound services such as water protection, tourism, sequestration of CO_2, and others. The first is the Sectoral Innovation System (SIS) approach. The second is the Regional Innovation System (RIS) approach, which has a more territory-oriented focus, looking at the innovation process at local or regional levels (Carlsson and Jacobson 1997). Asheim and Isaksen (2001) describe RISs as regional clusters that are supported by surrounding organizations. They argue that a RIS is, in principle, constituted by two key actors, firms in the regional clusters and institutions that create an institutional infrastructure. Thus, the concept of RIS is related to cluster concepts, however, the latter does not have innovation at its core and is not built around a systemic, conceptual model of actors, institutions, or interactions.

Sectoral Innovation Research in the Forest Sector

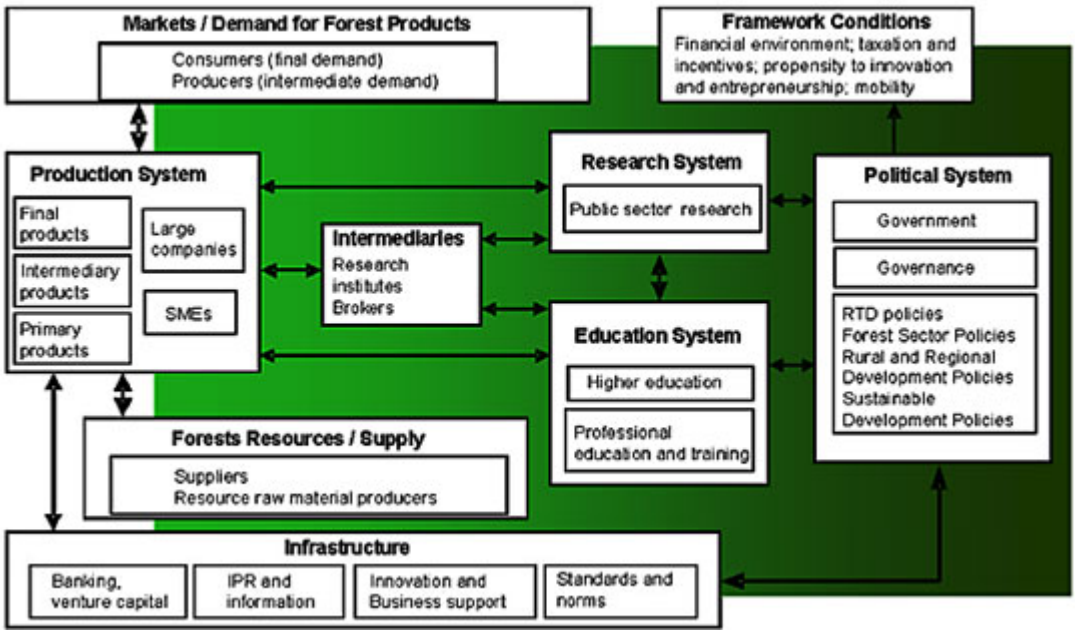
In agricultural innovation research, the concept of "agricultural innovation systems" is a rather well established research discipline; however, until recently, the concept of innovation systems was rarely applied in forest sector research or forest sector policy. That said, this approach has been used by Segura-Bonilla (1999, 2003) to develop the concept of sustainable systems of innovation in the context of forest services in Costa Rica. Coté (2002) used the innovation system concept in analyzing the Canadian forest sector. Rametsteiner et al. (2005), Kubeczko et al (2006), and Pickenpack (2004) used it to study innovation among forest holdings in several European countries. Based on representative surveys among forest owners in several Central European countries, Rametsteiner et al. (2005) and Pickenpack (2004) found that the frame conditions for innovation in forestry are often not supportive to innovation. Nonetheless, larger forest holdings are quite active in implementing incremental innovations, mainly to reduce costs of operations. Radical innovations, however, are lacking. Equally lacking are institutional frameworks and policies that would promote cross-sector interaction and innovation in the sector (Kubeczko et al. 2006, Rametsteiner et al. 2005). Interviews conducted among innovation system actors showed that decision makers in forest administration and in interest groups often overestimate the role of administrative impediments and underestimate the importance of market information in supporting innovation. More recently, the government of Canada announced a new Forest Industry Competitiveness Strategy (Canada 2005), of which one explicit aim is to improve the overall performance of its national forest innovation system.

Breschi and Malerba (1997) and Malerba (no year) identify forestry in a category that they call "traditional SIS", also found in agriculture. Typically, more process innovations than product innovations are introduced in a traditional SIS. Process innovations focused on reducing costs are especially emphasized. This is confirmed for forestry by Kubeczko et al. (2006) who find that SIS in forestry focus mainly on process innovations.

In studying innovation in the forest sector, Segura-Bonilla (1999) notes that path dependence and the institutional system are paramount in the formation of sectoral systems of innovation. Different natural resources and production conditions of a region influence the path of firm development and the whole sector. Firms, therefore, operate within this particular structure and establish routines and norms, which generally are stable for long periods of time.

In analyzing how far sectoral or regional innovation systems support the innovation performance of forest holdings, Kubeczko et al. (2006) found that innovations in products and services are more often supported in cross-sectoral regional innovation arenas rather than in well-developed sectoral or regional innovation systems. Only the diffusion of product or service innovations is supported by forestry SISs. This implies that support in earlier innovation stages and more systematic cross-sectoral interaction would be needed to increase the rate of product and service innovation in the sector. **Figure 1** provides an overview of a forest-based SIS. This illustrates the many different organizations and companies that make up an innovation system.

Figure 1. Sectoral innovation system and its many interrelations.



Due to the focus on territorial specificities, the RIS approach is well suited to analyze issues related to rural development. As forestry has a traditional sectoral focus on wood production, other functions and services of forestry might remain without support from the SIS. An RIS and SIS are both characterized, although with a different emphasis, by a certain regional component. Therefore, a linkage between a SIS of forestry and a RIS within the same region might be advantageous. This is demonstrated by Weiss (2004), using the example of bioenergy from woody biomass, as well as for non -wood forest products by Weiss and Rametsteiner (2005).

Statistics Canada is using a systems-based approach to its surveys on innovation, including the forest sector. Anderson and Schaan (2002), as well as Lonmo and Schaan (2005), report on the forest sector specific results of the “Survey of Innovation” in 1999 and 2003, respectively. Both reports present empirical results on the type of innovations performed by firms, how these take place, what factors influence the decision to innovate (or not), and the impacts of innovation. Coté (2002)

described the innovation system of Quebec's forest sector using 33 indicators and a database detailing research projects. He focused primarily on the infrastructure and interaction patterns of research and practice, one crucial point of innovation systems, and found that Quebec has an acceptable infrastructure and programs for forest-related research, and that possibilities for interaction between researchers and innovation actors exist. However, mechanisms encouraging the mobility between research center personnel and organizations involved in forest sector business are still very scarce. Other work in Quebec has investigated the role of research centers and created a matrix, whereby those centers can better transfer knowledge to the forest industry (Van Horne et al. 2006).

Future Research Directions

As we have argued above, innovation research has a long and rich history and includes a wide range of approaches. Accordingly, the field is challenging to encapsulate through a straightforward typology as we have attempted. Still, this effort should help to consolidate our understanding of what is known in the field with respect to research on the forest sector. Based on this synthesis of the state-of-the-knowledge in the field, we hope to motivate researchers to further explore the boundaries of innovation knowledge. Research results that can give clear direction for the forest industry are especially critical as the industry strives to remain competitive. Research should cover the entire value chain, including improvements needed in forests and forest management. In the following, we outline what we feel are key issues for consideration in future research that will benefit the broad field of forest sector innovation study.

Forest sector innovation research could benefit from a number of methodological improvements. Valid and reliable measurement of innovativeness is possibly the most significant challenge. Identification of innovative firms can be done in a number of ways and the forest sector literature has largely relied on identifying early adopters and equating them with the most innovative companies. As we discuss below, this method of measuring innovativeness requires further development. Also, other measurement approaches should be developed since they may present additional insight into innovativeness.

Innovation researchers have long advocated for inclusion of a temporal dimension in research since the innovativeness of firms may cycle through time (Subramanian 1996). Longitudinal studies are logistically and financially challenging, but could significantly enhance our understanding of innovative organizations. Many times, subjective measures of innovativeness are used, based upon a single respondent within a firm. Multiple respondents from one organization may improve measurement, but introduce data collection challenges as well as inconsistencies among respondents within one firm (Knowles 2006).

Organizational Innovativeness

Organizational Innovation

An ability to create and be creative is closely connected with firm culture, suggesting that a measurement approach more closely tied to culture may be fruitful. A large body of literature in psychology explores creativity with respect to firm culture (e.g., Amabile 1997). It can easily be argued that innovation should not be studied in isolation from firm culture (Crespell 2006). Although general literature on this topic is extensive, little work has been conducted in the forest sector. An improved

understanding of organizational culture in the sector should provide insight into where molding of culture may facilitate improved innovativeness.

Most research questions in the literature revolve around the ability to identify firms that are most innovative and relate that innovativeness to other firm characteristics and firm performance. For example, given the tradition and context of the forest products industry, it could be argued that pursuit of process innovation, high throughput, and low costs is the most profitable strategy. On the other hand, until a better understanding of the relative impact of different forms of innovativeness is developed, it is unclear what types of innovativeness provide the most promise for enhanced firm profitability. Previous research has shown that a balanced level of product, process, and business systems (administrative) innovation is more advantageous to firm performance (Damanpour et al. 1989). Arundel (2005) separates firms into categories based on their approaches to innovation. For example, strategic innovators actively pursue R&D while technology adopters primarily adopt innovations developed by others. He emphasizes that each approach can be equally successful for the individual firm. With this information in mind, development is especially needed to understand how to best invest resources among types of innovations as well as approaches to innovation. Enhancing specific aspects of the firm and its culture may be desirable since the form of innovation that better fits a company will depend on its culture and strategic orientation (Deshpande et al. 1993).

Adoption and Diffusion

As mentioned above, much of the forest sector research bases identification of innovative firms on their adoption of new products. Innovation adoption would be better understood if researchers took into greater consideration the impact of inter-product interactions in the innovation adoption and diffusion process (Bayus et al. 2000). It is well known that complementary product(s) can positively influence the adoption and diffusion of a new product, but the factors mediating and/or moderating this effect are poorly understood (e.g., Bigoness and Perreault 1981). Inter-product interaction is important to understand as an increasing number of wood-based products are marketed as product "suites," "systems,", and "bundles." In North America, for instance, Trus Joist® (a Weyerhaeuser business) markets the FrameWorks® Floor System to residential builders that integrates the company's laminated strand lumber, rim board, and beam products, with their wood I-joists to result in a floor system that does not squeak.

Scant attention has been given to the concurrent adoption of complementary products. Critics of research studying the adoption of a single innovation cite that the adoption of the innovation may be idiosyncratic. As a result, a single innovation may not be a valid or reliable measure of innovativeness that can be generalized to a larger set of innovations or potential class of adopters.

On the other hand, critics of research studying the adoption of multiple innovations, which traditionally employ dependent measures based on summated indices of adopter innovativeness, point out that innovation should not be implicitly assumed to be homogeneous. In other words, multiple innovation studies are criticized because they implicitly assume that factors that affect the adoption of the innovations being studied are homogeneous. Downs and Mohr (1976) strongly criticize the use of summated indices of innovativeness based on the adoption of multiple products. They argue that summated indices ignore the variations in the characteristics of particular innovations and the influence that these variations may have on the adoption decision. However, industry studies of

innovation are typically based on external reference sets and general content domains. Use of summated indices in this context provide a stronger basis to make deductive statements concerning the differences between innovation adopters and non-adopters.

Unit of Analysis. — A fundamental issue in innovation adoption research deals with the unit of analysis and how to evaluate the adoption itself. Should examination of innovation adoption of forest sector innovations be made strictly from the perspective of the firm, the individual, or both? Some researchers argue that the appropriate unit of analysis in innovation adoption studies is the individual (e.g., Rogers and Shoemaker 1971). Other researchers, however, argue that organizations should also be considered as a unit of innovation adoption analysis (Baldridge and Burnham 1975, Downs and Mohr 1976, Kimberly and Evanisko 1981); an argument persuasive enough that Rogers (2003) integrates organizational adoption theory into his diffusion of innovations framework.

Measurement of the Innovation Adoption Process. — Rogers (2003) extensively describes the general process of innovation adoption and proposes five stages of innovation diffusion: knowledge, persuasion, decision (adopt/reject), implementation, and confirmation. Nearly all of the innovation adoption research in the forest sector has focused only on the adoption decision itself (i.e., adopt/reject). Future research focusing on the entire process of innovation adoption (i.e., measuring innovativeness) would very likely lead to a greater understanding of the rationale behind the adoption/rejection decision, as well as a greater understanding of why some adopted innovations are occasionally discontinued by their adopting market. A key question that arises, however, is how should the innovation adoption process be empirically captured for analysis? Based on a meta-analysis Tornatzky and Klein (1982) conclude that the ideal dependent measure of innovativeness should include adoption and implementation. They indicate that this approach would increase the validity of the dependent variable since it would more fully account for the adoption process, through utilization and routinization, and not only the adoption decision.

The general innovation literature recognizes multiple innovativeness measurement methods and concludes that an important critique of innovativeness work is inconsistent operationalization of the construct (Subramanian and Nilakanta 1996). Within the adoption/diffusion research stream, use of single versus multiple products is an example. There are, however, many other ways to assess innovativeness such as creation of intellectual property, number of new products, and investment in R & D (Knowles 2006). Very few of these have been explored in the context of the forest sector. In addition, the work focusing on adoption/diffusion typically fails to incorporate creativity or the creation of innovation, something advocated by Subramanian (1996).

New Product Development

This field of research in the forest sector presents numerous opportunities to further the science and contribute to practical information for industry. From the limited information available about industry practices, it is apparent that the overall industry lacks a consistent and sophisticated approach to NPD. This is likely tied to the traditional production orientation of much of the industry, but we do not fully understand why the industry is not more systematic in its product development efforts. A positive start in this area would be an in-depth look at the barriers that exist within companies to more advanced methods of NPD. This suggests that qualitative methodological approaches may be most

fruitful in exploring why some firms in the industry successfully embrace structured NPD while others largely ignore the issue.

It may be argued that the commodity nature of many forest industry product lines prohibit large investments in NPD. However, the counter argument is that firms in this sector must use product innovation to avoid the commodity trap and assure long-term success. Ultimately, researchers must develop a better understanding of this interaction and, as mentioned above, how it may be related to firm culture. There may also be useful insights to gain from better understanding the impacts of innovation systems on the innovation investments chosen by firms. As outlined by Kubeczko et al. (2006), sectoral innovation systems in forestry focus on process innovations. Facilitation of other types of innovations may require improved policies.

Given the historical production orientation of the industry, an enhanced understanding of customers would be beneficial for both every day operations as well as for future product development. Therefore, voice of the customer research is badly needed to begin understanding how customers and consumers use wood products as well as discovering their latent needs. Better insights into customer needs could facilitate increased attention on innovation by the forest sector.

Innovation Systems Research

The innovation systems model, despite the need for further development, is a promising approach for both scientists and forest policy makers. The systems approach provides a fresh set of perspectives on the fundamentals of innovation processes. It enables reframing and reconceptualizing of the problem, suggesting that success is as much a matter of choosing and managing relationships with organizations and persons outside the firm, both market and non-market related. Systems approaches are useful for analyzing complex and interrelated phenomena such as innovation and the contextual conditions under which these come about in terms of actors, institutions, and interactions. The concept underlying systems approaches is not based on a theory that enables the empirical validation of the influence of individual factors. This, however, is not necessarily needed for providing advice on how to create, design or redesign, manage, or transform innovation systems. While being a rich and fruitful approach to analysis, further work is needed to both ground the concepts in theory and to enhance its applicability in practice.

The following are particularly important areas of further research, both on the concept in general and for forest sector related applications. First, further research is needed on different typologies of innovation systems, in addition to national, regional, and sectoral ones. These typologies could focus more on the intended outcome of innovation, e.g., different types of products or services where key characteristics differ, e.g., the type and role of technological knowledge. Typologies along these lines would enable better identification of ideal-type system structures for specific innovation goals in a sector or an economy. For instance, in forestry, it is conceivable that advancing innovation in forest related bio-energy would need a different type of set up for an innovation system than a service innovation. Some of these systems would need a specific territorial component with a strong social capital knowledge and learning at the center, while innovation in wood products would benefit from more technological knowledge interaction focus along the value chain.

A second fundamental area for general as well as forest sector specific research on the systems approach concerns the dynamic or evolutionary nature of innovation systems. Current research has a strong focus on comparing the structure of different systems and thereby explaining the differences in performance. A better understanding of the evolution of innovation systems, related characteristics, and conditions is crucial, yet is so far hardly in the focus of research.

Another research area concerns the further development and typological differentiation of system functions and system failure concepts for different conditions and their measurement. This should also drive home the message that there is no one-size-fits-all system and that the comparison of performances of too small a number of systems working under very different conditions would possibly not result in fruitful outcomes. Research in this area would possibly benefit from looking specifically to crucial actors and interactions in innovation systems, such as the interaction between firms and research as well as between firms and potential future users of innovation.

A final area of research is the role of public policies, including how administration in a sector such as forestry can best contribute to the emergence of an environment or a governance system that is conducive to innovation. So far, it seems governments rely too much on financial incentives whereby innovation, too often is in fact not an explicit policy goal.

Managerial Practice

Innovation performance is increasingly believed to be the ultimate factor distinguishing poor performers from industry leaders. If growth through innovation is the goal of a company, it clearly cannot be reliant on happy accidents. The managerial challenge is to create the conditions for innovation, and as indicated in this paper, there is an increasing body of knowledge on which to base decisions. Managerial implications were not directly addressed in the context of this synthesis article. However, even though the innovation literature includes conflicting findings, existing knowledge can be used as a basis for approaching innovation as a systematic, enterprise-wide process. It is important for practitioners that research findings be broken down into concepts, tools, and rules to follow for easier practical application. There is a clear need for further interpretation of current findings and identification of implications for industry practice as well as research exploring new territory.

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