

Information Technology Adoption in US and Canadian Forest Products Industries

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Abstract

Information technology (IT) has advanced at a rapid rate during the past three decades, and when used well, IT can bestow a competitive advantage in the modern economy. This article reviews key studies on IT adoption in US and Canadian forest products industries, summarizes their common findings, gives insights on these commonalities, and recommends future areas of research. The most frequent conclusion of these studies was that most forest products firms used only basic ITs. IT adoption rates were often found to be positively correlated with firm size and proportion of sales from exports. Most firms invested less than \$10,000 in IT, which was not enough to develop sophisticated IT. Firms often perceived the largest benefits of IT to be promotional in nature, while cost-cutting operational benefits were usually ignored. Overall, with the exception of the pulp and paper industry, a cautious attitude toward IT adoption was observed. The low IT adoption by this sector could be attributed to several factors, such as being a highly production-oriented industry with few IT savvy personnel.

The rising importance of information technology (IT) in manufacturing is illustrated by the fact that US and Canadian manufacturing firms invested \$55.5 billion and \$3.1 billion in information and communication technologies (ICT) in 2008, respectively, which represents a more than threefold increase in these types of investments compared with 1987 (Centre for the Study of Living Standards [CSLS] 2009). The presence of software, hardware, and network communications has been found to be positively and significantly correlated with labor productivity and market share in Canadian manufacturing firms. The strongest correlations were found in firms that implemented all three types of technology simultaneously (Baldwin and Sabourin 2001).

One of the first empirical studies to investigate the value of IT investments found no consistent evidence of a positive relationship between IT investment and firm performance (Weill 1992). Brynjolfsson (1993) argued that although computing power had been growing rapidly during the past few decades, productivity had been stagnating in several sectors, coining the phrase “productivity paradox of information technology.” After scores of conflicting studies, researchers began to realize the importance of intangible costs and benefits in assessing the value of IT investments (Irani 2002). Brynjolfsson and Hitt (1998) explained that intangible benefits form the majority of value from IT investments. Therefore, it has been recognized that although

IT alone cannot provide competitive advantage, it is an *enabler* of it, especially through business process redesign (Mooney et al. 1996).

IT can provide benefits in three general ways. First, it can improve firm performance through process automation, thus increasing labor productivity and lowering labor costs. Second, ITs allow companies to redesign their business processes to make them more efficient and more closely aligned with corporate strategy. Third, they assist in the formation of collaborative and interorganizational relationships that can open new markets (Hetemäki and Nilsson 2005).

With the exception of the pulp and paper industry, IT adoption in forest products firms has been below the manufacturing sector average. For example, in the period 1999 to 2000, half of all US manufacturing firms (North

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American Industry Classification System [NAICS] 31–33) had at least one computer network in place, while 43.5 and 35.3 percent of wood products (NAICS 321) and furniture (NAICS 337) plants reported having a computer network. Similarly, 2.9 percent of wood products and 3.3 percent of furniture plants used enterprise resource planning, compared with 8.2 percent of all manufacturing plants (Atrostic and Gates 2001).

Numerous studies have focused on IT adoption in the US and Canadian forest products sector. The majority of these studies were an assessment of the current level of IT use in the sector. Researchers also wanted to gauge attitudes toward IT and the perceived barriers to adoption. A few studies investigated the influence of demographic and firm-type variables on IT adoption rates. This article reviews these important studies, summarizes their common findings, gives insights on these commonalities, and recommends future areas of research.

IT Adoption in Forest Products Industries

Studies on IT adoption in US and Canadian forest products industries began in 1996, with the majority occurring in the first half of the 2000s (Table 1). Most studies were carried out via industry surveys, and subsequent analyses ranged from simple percentage calculations to multivariate statistical analyses.

Vlosky and Gazo (1996) pioneered research in this area with an exploratory survey of Forest Products Society members. At that time, the Internet was just starting to gain popular acceptance, and its variety of uses were beginning to be explored. The goal of this study was to discern which Internet-enabled services were of highest interest to Forest Products Society members. Access to industry information and forest products databases was seen as the most valued service.

Industry-wide surveys began with Vlosky and Fontenot (1997). They surveyed 364 primary and secondary wood products firms across the United States to examine their current use of and future plans for using the Internet for business purposes. Although most respondents (52%) had Internet access, less than one-third of them (28%) had a company website. While secondary manufacturers had a greater Web presence than primary manufacturers, a greater percentage of primary manufacturers were planning on developing a website in the near future (80% vs. 20%). Most firms were using or planned to use e-mail and company websites for customer communication and product promotion, but fewer than 10 percent were using or intended to use the Internet to facilitate purchases and sales. The greatest perceived benefit of the Internet was greater exposure to customers, while the lowest perceived benefit was lower prices to customers.

In a similar survey, Vlosky (1999) expanded the sample to include Canadian firms and the pulp and paper industry. Results from this survey indicated that IT adoption in the forest products sector was slow. Most respondents (60%) reported not using the Internet for any business activities, and approximately one-third of them (34%) did not plan on using such technologies in the future. A positive correlation was found between firm size and Internet adoption rate. Investment in Internet technologies was found to be minimal, with 44 percent of adopting firms investing less than \$10,000 cumulatively. The highest ranked perceived benefit was increased access to industry information, while

the lowest ranked benefit was lower prices to customers. The biggest concern regarding Internet technologies was the security of sensitive information. Most adopting firms were not satisfied with their IT implementation in terms of completion time and benefits received. This coincided with half of the firms not conducting or planning to conduct an audit of their IT projects. The lack of formal review could have been a major contributor to the firms' disappointment.

Pitis and Vlosky (2000a, 2000b) surveyed 104 US primary wood products exporters in 1999 to examine their use of Internet technologies in business activities. In that study, 82 percent of respondents reported using the Internet for business purposes, much higher than previous studies. Companies with higher revenues were statistically more likely to use the Internet, as Vlosky (1999) found. E-mail was the most commonly used Internet technology (94%), followed by Web navigation (81%). Nearly half of the firms (49%) reported spending less than \$10,000 in total on Internet technologies. The highest ranked perceived benefits of using the Internet were increased access to industry information, greater access to one's company, and an enhanced image of one's organization. None of the impediments to implementation (technical issues, internal factors, acceptance of technology) were perceived to be very strong. Although three-fourths of respondents were at least somewhat willing to sell their products online, one-fourth strongly opposed it. In summary, US primary wood products exporters were early adopters of Internet technology compared with other wood products sectors. There was widespread use of basic Internet technologies such as e-mail, but a cautious attitude still existed toward using the Internet for financial transactions in 1999.

A survey of 372 primary wood producers and pulp and paper mills was done by Dupuy and Vlosky (2000) to learn more about their adoption of Electronic Data Interchange (EDI). EDI is used to electronically transmit business documents, reducing operating costs and increasing responsiveness. In 1999, only 16 percent of the surveyed companies were using EDI, although 28 percent that were not using the technology planned to do so by 2002. Survey results showed that EDI use was highly correlated with firm size. The impetus to adopt EDI came primarily from their customers (e.g., home center retailers such as Home Depot and Lowe's) rather than internally. The lowest rated motivation to change was the potential cost savings. The critical success factors highlighted by those firms that had implemented EDI were the need to commit the necessary resources and willingness to change.

Few studies have focused solely on Canadian forest products firms and their IT adoption. Kozak (2002) represents one of the first such studies, where he examined the usage of and attitudes toward IT by 126 Canadian secondary manufacturers. By then, the Internet had been widely adopted in North America, reflected by 88 percent of survey respondents having Internet access. Internet use increased with firm size and tripled for firms with more than 100 employees. The most common Internet activities were online research, exchanging documents with partners, and e-mailing customers. Fewer than 10 percent of respondents used the Internet for purchasing products or e-mailing employees. Half of the firms had an active website in 1999. Websites were primarily being used to provide information to customers and increase exposure to potential customers. None of the company websites facilitated financial transactions. Survey

responses were separated into early and late adopters based on whether the firm had an active website or not. In general, firms producing higher-value products (cabinetry; moldings, millwork, and floors; homes; engineered wood products; doors and windows) were more likely to be in the early adopter group, with the exception of furniture manufacturers. The lower value-added pallet, box, shake, and shingle manufacturers were exclusively in the late adopter group. Overall, the British Columbia value-added wood products industry was receptive to using the Internet in business operations and confident that its use would increase in the future. However, the industry had yet to fully invest in IT and take advantage of the significant benefits (e.g., lowering supply chain costs) that more advanced technologies could provide.

Vlosky and Westbrook (2002) surveyed 70 top-level home center managers to examine the role of Internet technologies between home center retailers and forest products companies. Most respondents (78%) had a website, while one-fourth of them used the Internet for forest product purchases. No correlation was found between firm size and Internet purchases, signaling uniform adoption. The highest ranked perceived benefits of the Internet were increased access to industry information and greater exposure to potential suppliers. The biggest impediment to adoption of Internet-facilitated procurement was the fear of losing relationships with suppliers since wood procurement was still generally done through traditional communication. Moreover, many home centers did not intend to invest in these technologies since the perception was that few forest product companies were interested in forming such a partnership.

An in-depth analysis of the underlying demographic factors associated with IT adoption in secondary wood products firms was carried out by Shook et al. (2002). The study surveyed 780 secondary manufacturers in Montana, Idaho, and Washington in 1999. The effect of gross sales, sales from wood-based products, capacity utilization, number of full-time employees, and the ratio of wood to nonwood material costs on the Internet use of companies was assessed. A higher percentage of large companies compared with small companies had websites. Those firms with a website operated at significantly lower capacity (76% vs. 82%) and had higher employment (32% vs. 20%) than those without a website. Most respondents (53%) used e-mail in their business activities. Plant size and e-mail usage were found to be positively correlated, with e-mail usage in large plants being 70 percent higher than in small plants. Companies using e-mail in their business activities had twice the gross sales and 175 percent more employees as those not using e-mail. Overall, 21 percent of firms reported selling online and 22 percent purchasing online. Small firms were less likely to sell and purchase online than large firms. Firms that sold online derived a significantly higher percentage of their gross revenues from nonwood products and services and also had significantly lower overall plant utilization rates. Those that purchased business supplies over the Internet had significantly higher gross revenues and full-time employment. Overall, only 8 percent of manufacturers used Internet banking services. Firms that used the Web to conduct online research had higher gross sales and employment.

The Internet adoption of 55 primary wood products producers in the western United States was studied by Vlosky et al. (2002). Mail and fax were found to be vastly preferred over e-mail and EDI for business document

exchange. As in previous studies, greater exposure to potential customers and increased access to industry information were indicated to be the greatest benefits of the Internet. Offering lower prices to customers was perceived to be the lowest benefit.

Vlosky and Smith (2003) surveyed 195 US hardwood lumber firms to gauge their adoption of Internet technologies. A high percentage of respondents (90%) had used the Internet for business purposes. Slightly more than half of respondents (55%) reported having a company website, of which 48 percent used it for promotion and advertising, 12 percent for customer service, 9 percent for financial transactions, and 7 percent for internal operations. Mail and fax were found to be the most common methods for transmitting business documents, while the use of e-mail for this purpose was low and EDI nearly nonexistent. Hardwood lumber firms used the Internet primarily for applications such as e-mail communications and static website development. Half of the respondents invested less than \$5,000 in Internet technologies, and 19 percent invested between \$5,000 and \$10,000. Surprisingly, the majority of firms reported no serious impediments to implementation. The highest rated impediment was lack of IT staff. The highest ranked perceived benefits of using Internet technologies was greater exposure to potential customers, greater access to existing customers, and increased access to industry information.

Several Internet-based business-to-business forest products exchanges (e-marketplaces) failed after the dot-com crash of 2001. A survey by Shook et al. (2004) of 11 former and current executives of forest products e-marketplaces revealed many possible reasons for their decline. First, the aftermath of the 2001 dot-com crash put an overall damper on user adoption. Second, many executives cited an overall slower technology adoption rate in the forest products sector. They also stated that a hasty overpromotion of the technology had intimidated potential customers. The e-marketplaces' underestimation of the importance of the human factor in the forest products sector was a critical factor in their decline. Managers oftentimes found it easier to pick up the phone and discuss the minute details of a transaction with a person, rather than interacting with software. High switching costs and change management issues also inhibited adoption. Overall, e-marketplace providers oftentimes failed to show how their service added value to a business. E-marketplaces may have been more successful if they implemented their technology incrementally, instead of an all-or-nothing approach. Forest product companies are typically slower to adopt and could need more time to be eased into new technologies.

Janssen et al. (2004) surveyed US and Canadian pulp and paper mills on their use of ITs. The primary reason to justify the use of an information management system (IMS) was the need to store information more efficiently. All respondents agreed that the most important benefits of an IMS were the improved process data flow and the increased capabilities for problem solving resulting from process-related data. Time and financing constraints were the main barriers for IT adoption in these mills. Resistance to change from personnel was also perceived to be a significant barrier (60%). Overall, survey results showed that while the paper mills were relatively high users of IT, they had yet to fully exploit the potential of information systems, especially with regard to supply chain management.

Table 1.—Summary of studies on information technology (IT) adoption in forest product industries and their objectives.^a

Author	Year	Region	Industries	Objective	Methods	No. of respondents	Response rate (%)
Vlosky and Gazo	1996	US	Forest Products Society members	<ul style="list-style-type: none"> • Discern what Internet services are of most interest to Forest Products Society members 	Survey	508	19
Vlosky and Fontenot	1997	US	Primary and secondary products	<ul style="list-style-type: none"> • Examine current and potential use of e-commerce by US wood products firms for business operations and marketing 	Survey, statistical tests	364	36
Vlosky	1999	US and Canada	Lumber, plywood, OSB, particleboard, engineered lumber, treated wood products, veneer, pulp/paper	<ul style="list-style-type: none"> • Examine current and planned use of e-commerce by US and Canadian forest products firms 	Survey	234	18
Pitis and Vlosky	2000a	US	Logs, lumber, plywood, OSB, MDF, and particleboard	<ul style="list-style-type: none"> • Determine Internet use by US primary wood products exporters and identify benefits, impediments, attitudes, and expectations associated with the Internet 	Survey, Spearman's rank-order correlation test	104	46
Dupuy and Vlosky	2000	US and Canada	Pulp/paper, lumber, engineered lumber, particleboard, OSB, plywood, pallets, treated lumber, millwork	<ul style="list-style-type: none"> • Better understand the level of EDI implementation and use in wood product industry in 1999 	Survey, statistical tests	372	35
Pitis and Vlosky	2000b	US	Logs, lumber, plywood, OSB, MDF, and particleboard	<ul style="list-style-type: none"> • Better understand how US primary wood products exporters use the Web to conduct business 	Survey, Spearman's rank-order correlation test	104	46
Kozak	2002	Canada	Remanufactured products; cabinets; moulding, millwork, and flooring; homes; engineered wood products; doors and windows; pallets and boxes; furniture; fences; shakes and shingles	<ul style="list-style-type: none"> • Examine the perception, adoption, and future uses of computers and the Internet • Determine the current and future use of the Internet in business applications • Gauge the attitudes and beliefs toward use of the Internet in business applications • Determine the Internet readiness of the Canadian secondary wood industry • Identify strategies for hastening the adoption of e-commerce solutions 	Survey, Kendall's τ -b bivariate correlation analysis	126	12
Vlosky and Westbrook	2002	US	Home center retailers	<ul style="list-style-type: none"> • Examine current and potential Internet-facilitated buyer/seller exchange between home improvement/building materials retailers and solid wood products suppliers • Discern the general readiness of the improvement/building materials industry to do business through Internet-based technology • Identify concerns and perceived opportunities from participation in Internet-facilitated business practices 	Survey	70	29
Shook et al.	2002	ID, MT, WA (US)	Furniture, cabinets, millwork, building components	<ul style="list-style-type: none"> • Determine the extent that secondary forest products firms in the Pacific Northwest use e-commerce technology • Uncover the relationship between demographics and e-commerce technology usage 	Survey, Scheffe's contrast test, Kendall's τ -b bivariate correlation analysis	780	74

Table 1.—Continued.

Author	Year	Region	Industries	Objective	Methods	No. of respondents	Response rate (%)
Vlosky et al.	2002	CA, MT, ID, OR, WA (US)	Lumber, engineered lumber, plywood, OSB, particleboard, MDF	<ul style="list-style-type: none"> Examine the current and potential uses of the Internet in the primary solid wood products industry in the western United States Discern perceived benefits of using Internet technologies Identify level of importance of services and features offered by third-party Internet exchanges Discover current and potential uses of Internet technology in the US hardwood industry Determine the Internet readiness of the US hardwood industry Identify criteria for participating in third-party online exchanges Identify industry concerns with Internet technologies Determine why some e-marketplaces failed and some survived during the dot com crash Determine current and future usage of IMSs Identify justification and implementation methods for IMS being used in the industry Identify prerequisites and barriers to system integration Determine current and future Internet technology usage by wood products firms in New York and Louisiana Determine the important factors in IT adoption for BC secondary wood products firms Determine attitudes toward and barriers to IT adoption in Quebec forest product firms Determine if the adoption rate is equally distributed across the industry Ascertain whether the industry intends to use more IT in the future Determine the level of Internet usage and perceived benefits and constraints of IT adoption 	Survey, statistical tests, factor analysis	55	26
Vlosky and Smith	2003	US	Hardwood lumber, lumber distributors, furniture, flooring, pallets, cabinets	<ul style="list-style-type: none"> Discover current and potential uses of Internet technology in the US hardwood industry 	Survey, statistical tests	195	12
Shook et al.	2004	US and Canada	E-marketplaces (third-party online exchanges)	<ul style="list-style-type: none"> Determine why some e-marketplaces failed and some survived during the dot com crash Determine current and future usage of IMSs Identify justification and implementation methods for IMS being used in the industry Identify prerequisites and barriers to system integration 	Survey	11	41
Janssen et al.	2004	US and Canada	Pulp/paper	<ul style="list-style-type: none"> Determine current and future Internet technology usage by wood products firms in New York and Louisiana Determine the important factors in IT adoption for BC secondary wood products firms 	Survey	n/a	n/a
Holmes et al.	2004	NY, LA (US)	Wood products, crafts	<ul style="list-style-type: none"> Determine current and future Internet technology usage by wood products firms in New York and Louisiana Determine the important factors in IT adoption for BC secondary wood products firms 	Survey, statistical tests	109, 38	33, 18
Stennes et al.	2006	BC (Canada)	Remanufactured products, cabinets, furniture, millwork, engineered wood products	<ul style="list-style-type: none"> Determine attitudes toward and barriers to IT adoption in Quebec forest product firms Determine if the adoption rate is equally distributed across the industry 	Survey, regression	393	51
Karuranga et al.	2006	QC (Canada)	Sawmill, value-added building materials, furniture, pulp/paper	<ul style="list-style-type: none"> Determine attitudes toward and barriers to IT adoption in Quebec forest product firms Determine if the adoption rate is equally distributed across the industry Ascertain whether the industry intends to use more IT in the future 	Survey, ANOVA, Duncan post hoc analysis	312	45
Arano	2008	WV (US)	Primary and secondary hardwood products	<ul style="list-style-type: none"> Determine the level of Internet usage and perceived benefits and constraints of IT adoption 	Survey	56	21

^a OSB = oriented strandboard; MDF = medium-density fiberboard; EDI = Electronic Data Interchange; IMS = information management systems; ANOVA = analysis of variance.

A study by Holmes et al. (2004) investigated the Internet use of small wood products manufacturers in New York and Louisiana. Nonresponse bias was detected; thus the study is considered exploratory in nature. Overall, the usage of e-commerce technologies was found to be low, although New York had higher usage levels than Louisiana. Although only 44 and 36 percent of New York and Louisiana firms had a website, respectively, respondents from either state did not indicate any serious impediments to website development.

Stennes et al. (2006) used logit regression on survey results from British Columbian secondary manufacturers to determine factors that influence e-commerce usage. The effects of variables, such as wood volume, proportion of domestic market sales, and firm type (remanufacturers, engineered wood products, millwork, and furniture/cabinets), on having a website, Web procurement, and sales over the Internet were assessed. Wood volume and firm type were found to have a significant ($\alpha = 0.10$) positive relationship on having a company website. There was a significant ($\alpha = 0.10$) negative relationship between remanufacturers and sales over the Internet. Also, furniture and cabinet firms were most likely to engage in Internet procurement. All three regressions indicated that exporting firms were more likely to engage in these three e-commerce activities.

The IT adoption of 312 forest product firms in Quebec was studied by Karuranga et al. (2006). Overall, 64 percent of respondents had a company website. Paper and carton mills (90%) were more likely to have a website compared with building material plants (59%) and sawmills (56%). Annual revenue was also found to be a significant distinguishing variable, with higher revenue companies being more likely to have a website. Corporate websites and accounting software were the most ubiquitous applications of IT. Conversely, usage rates for IT in operational planning, supply planning, inventory management, process control, and buying/selling were very low (less than 5% for all technology groups). Once again, industry type emerged as a distinguishing factor in IT use. Furniture manufacturers were much less likely to engage in online financial transactions, while paper and carton mills were more likely to use IT in different internal operations. Greater access to industry information was the primary perceived benefit of using IT. As in other studies, 82 percent of respondents stated that information security was a very important barrier to adoption, while 70 percent identified the lack of trained IT personnel as an important barrier.

Arano (2008) surveyed West Virginian hardwood manufacturers on their IT adoption and reported several findings similar to previous studies. Most respondents (46%) reported investing less than \$10,000 on e-commerce. A significant positive correlation was found between firm size and e-commerce adoption. A similar relationship was observed between gross sales revenue and e-commerce adoption. Exporting firms were more likely to use e-commerce. The greatest perceived benefits of e-commerce were improved service to customers and greater exposure to potential customers, while lower prices to customers was shown to be the lowest perceived benefit. Security of sensitive information was the biggest concern among firms in adopting e-commerce into their business operations. In contrast to earlier studies, though, over 75 percent of adopters reported using Internet

technologies for e-mail, supply purchasing, company website, and taking customer orders over the Internet.

Discussion

A review of these studies revealed many common findings between them (Table 2). First, nearly all studies noted a lack of using advanced Internet technologies in wood products companies. Examples of advanced Internet technologies include e-commerce for online financial transactions and EDI for transmission of digital business documents. Most of the surveyed firms reported using the Internet primarily for e-mail, static websites, and research on the Web. ITs with increasing complexity are those for competitive assessment activities, value-chain linkages, and business processes (Pitis and Vlosky 2000a). Vlosky and Smith (2003) describe the differentiation between ITs as lower-order versus higher-order technologies, with the latter group requiring networking and connectedness to business systems both internally and externally. This observation mirrors the model of Internet business strategy evolution where companies begin in the "information" space and then progress through the "communication," "distribution," and "transaction" space (the ICDT model). Information space refers to new channels for displaying product, service, and company information. Communication space consists of new channels for relationship-building activities. Distribution space refers to new channels for distributing products and services. Transaction spaces are new avenues for executing electronic sales and purchases (Angehrn 1997). Research thus far has shown that the majority of forest products firms are in the information and communication space (e.g., static websites and e-mail), and relatively few have entered the distribution and transaction space (e.g., online transactions and supply chain management technologies).

Another major trend in the studies was the observation of a significantly positive correlation between firm size and IT usage. For example, Shook et al. (2002) found that respondents using e-mail had mean gross sales of \$4.81 million versus \$1.99 million for nonusers (significantly different at $\alpha = 0.05$). Companies that used the Web to do business research also reported mean gross sales of \$4.25 million versus \$2.18 million for companies that did not (significantly different at $\alpha = 0.05$). Those firms engaging in the previously stated Internet activities also reported significantly higher employment. This correlation was also noticed in higher-order technologies. A 1999 survey of US and Canadian primary wood products and pulp and paper producers found that firm size was highly correlated with EDI use (Dupuy and Vlosky 2000). Stennes et al. (2006) found a significant positive correlation ($\alpha = 0.05$) with firm size and presence of a website, but not Internet sales and purchases. These findings agree with a large body of previous research showing that firm size has a large impact on IT adoption, in both manufacturing and nonmanufacturing industries (Cohen 1995, Lal 1999, Sabourin and Beckstead 1999, Hollenstein 2004).

In addition to firm size, percentage of sales from exports also had a positive influence on IT adoption (Table 2). Pitis and Vlosky (2000b) were early to notice this trend, but firm statistical evidence was unavailable at the time. The relationship was statistically validated by Stennes et al. (2006) when they observed that the proportion of domestic market sales was negatively related to website presence and

Table 2.—Major findings of selected information technology (IT) studies specific to forest products industries.

	Vlosky and Gazo (1996)	Vlosky and Fontenot (1997)	Vlosky (1999)	Pitis and Vlosky (2000a)	Pitis and Vlosky (2000b)	Dupuy and Vlosky (2000)	Vlosky and Westbrook (2002)	Vlosky et al. (2002)	Shook et al. (2002)	Kozak (2002)	Vlosky and Smith (2003)	Holmes et al. (2004)	Stennes et al. (2006)	Karuranga et al. (2006)	Arano (2008)
Most firms used the Internet for lower-order applications like e-mail, static websites, or online research		x	x	x	x		x	x	x	x	x			x	x
Size of firm and IT adoption rates were positively correlated			x	x	x	x			x	x			x	x	x
Most firms invested <\$10,000 in IT			x	x	x	x		x		x	x			x	x
Greater access to industry information was one of the highest perceived benefits of using Internet technologies	x						x							x	
Lowering costs was one of the lowest perceived benefits of using Internet technologies															
Information security was the top concern in IT adoption		x				x									
Exporting firms were more likely to use IT than nonexporting firms														x	

Internet sales/purchases. These findings are not surprising because the Internet is particularly well suited to benefit exporters through lower documentation, communication, promotion, and transaction costs (Hetemäki and Nilsson 2005).

In 2008, the mean IT investment per employee in the manufacturing sector was \$3,489 in the United States and \$1,480 in Canada (CSLS 2009). While the reviewed studies did not report per employee figures, their findings that the majority of surveyed companies invested less than \$10,000 in total is indicative of below-average IT investment levels (Table 2). While this amount may be sufficient for developing lower-order technologies (information and communication space in the ICDT model), it is not adequate for high-order technologies (distribution and transaction space in the ICDT model; Kozak 2002).

There was a general consensus among primary and secondary manufacturers that greater access to industry information was one of the greatest benefits of IT (Table 2). While Janssen et al. (2004) reported that 90 percent of surveyed executives in the pulp and paper industry realized the ability to store information more efficiently was the top benefit. This indicates that pulp and paper firms expected more from their IT investments than primary and secondary wood products firms. This is likely a direct result of the paper industry's more sophisticated use of IT. It is noteworthy that all of the studies were survey-type and therefore reported perceived benefits. There were no empirical studies of firm performance before and after IT implementation to quantify actual benefits.

The ability of IT investments to lower costs is arguably one of its more important benefits. However, lowering prices for customers and lowering operational costs were often perceived as less important benefits of using IT for wood products firms, while greater access to industry information was the highest perceived benefit (Table 2). This perception was first observed in 1996 and has continued throughout the last decade with a more recent study in 2008. Additionally, Brynjolfsson and Hitt (2000) suggest that the most significant long-term benefits are the improvements in business processes and organizational structure that can arise from successful IT investments. None of the reviewed studies indicated that forest product companies perceived these as important benefits. These survey responses support the conclusion that most wood products manufacturers are not realizing the full potential of IT investments.

Information security is a serious concern for all industries, and attention to this topic is increasing. Its importance is highlighted by the \$30.3 billion dollars spent on IT security in 2005 (Garg et al. 2003). Forest products companies have similar concerns, with four studies reporting that information security was a top issue (Table 2). This partially explains the cautious attitude toward IT adoption that Pitis and Vlosky (2000a) observed, especially in regard to online financial transactions.

Conclusions

With the exception of pulp and paper companies, US and Canadian forest products companies have been slow in integrating IT into their business. IT adoption has been primarily in lower-order technologies such as e-mail and static websites. There is likely a confluence of factors that contribute to this. The significant influence of firm size on

level of adoption is an important finding because the secondary wood products industry is highly fragmented in both the United States and Canada (Hetemäki and Nilsson 2005). This does not, however, explain slow IT adoption by primary wood product industries that tend to be larger and more capital intensive. The cause here may be linked to corporate orientation.

US primary wood producers have historically been production oriented, where the focus is on the product and improving the production process. A marketing orientation is becoming increasingly important in the modern economy. A firm with this orientation focuses on the needs and wants of the customer, adjusting their offerings accordingly. In a study of US primary producers, Poku (2003) found that firms with a high level of market orientation had higher levels of IT adoption than low market orientation firms. It should be noted that many larger sawmills use networks of programmable logic controllers linked with high-speed Ethernet to control their machinery. While this is certainly a form of IT, it was not within the scope of the reviewed studies and hence is not included in this literature review.

Slow IT adoption could also be due to a workforce that is not technologically savvy. A relatively low-skilled workforce is common in many forest product industries (Hetemäki and Nilsson 2005). A recent study on the decline of the US furniture industry asked respondents to gauge the effect of labor force issues on their business. They indicated that an inability in finding a sufficiently skilled workforce was making it difficult to make investments in new technologies. Firms also stated that they had to pay more than they wanted for technologically savvy workers (Grushecky et al. 2006). Another study reports that the greatest determinant of IT adoption success in US forest products firms was the quality of IT staff (Poku 2003).

Finally, the degree of value added in a product may influence IT adoption. Kozak (2002) found that secondary industries with higher priced custom products (e.g., engineered wood products and millwork) were more likely to adopt IT and have a Web presence than firms selling lower priced commodity products (e.g., pallets, boxes, and shingles).

The majority of the literature reviewed here is an assessment of the low IT adoption rate in forest products industries. Only a few studies have begun to investigate why the adoption rate may be so low. Corporate orientation, human capital, and value-added factors have begun to receive attention, but further research could be done to give more insight on why adoption is so low. Additionally, more research on the pulp and paper industry could reveal why and how that industry has adopted IT much more rapidly than others in the sector.

Comprehensive data on IT expenditures currently exist for the main industry sectors (level 2 NAICS codes, i.e., manufacturing, services, finance, etc.). More detailed data on IT investment amounts for industry subsectors (NAICS 321 [Wood Product Manufacturing], 322 [Paper Manufacturing], and 337 [Furniture and Related Product Manufacturing]) would enable a more rigorous comparison of forest products industries against other manufacturing industries. More detailed investment data would also allow for better IT benchmarking within the forest products sector.

IT changes rapidly, and most of the studies in the area took place in the first half of the 2000s. Furthermore, as the costs of IT continue to decrease, the previously observed positive correlation between firm size and adoption rates

may have changed due to lower capital requirements. Therefore, more research efforts could be done to investigate how IT adoption in the wood products industry has changed during the past few years.

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