Evaluation of Strategic Software Investments for the Canadian Cabinet Industry

Richard Hewitt
Taraneh Sowlati
Joseph C. Paradi

Abstract

Software investments are increasingly important to remain competitive in modern manufacturing. However, wood product industries generally make minimal information technology (IT) investments and are slow adopters. This study determines the types of software that could contribute the most to the future competitiveness of the Canadian cabinet industry using industry and IT expert input into an Analytic Network Process model. Findings include the following. The *Quality* strategy is the most crucial for the industry's future competitiveness, with a normalized weight of 0.332, and the *Delivery* strategy is the least important (0.111). For software, *Operations & Engineering* and *Enterprise Resource Management* applications are the most important, having final priorities of 0.227 and 0.222, respectively. *Content* applications are relatively unimportant (0.087). The sensitivity analysis indicates that the results are robust for varying weights of all strategies except *Customer Service*. A higher emphasis on the Customer Service strategy increases the priority of the *Customer Relationship Management* and *Collaboration* applications to the first and the second-highest priority, respectively.

Information technology (IT) is becoming increasingly ubiquitous in modern manufacturing. The share of IT investment in all capital investments increased from 3.7 percent in 1981 to 19.3 percent in 2011 in the Canadian manufacturing sector and from 16.8 percent in 1987 to 23.0 percent in 2010 in the US manufacturing sector (Centre for the Study of Living Standards [CSLS] 2012). The effective use of IT in manufacturing could help firms pursue more profitable business strategies and increase production efficiencies (Bartel et al. 2005). Additionally, the presence of hardware, software, and network communications has shown a strong positive correlation with labor productivity and market share in Canadian manufacturers (Baldwin and Sabourin 2001).

Despite the increasing influence of IT on manufacturing competitiveness, the North American wood products sector has had a lower IT adoption rate than the manufacturing sector as a whole (Atrostic and Gates 2001). Previous studies on IT in wood products industries have generally concluded that secondary wood manufacturers made minimal investments in IT (<US$10,000) and used less-advanced forms (e.g., static Web sites, Internet, e-mail; Hewitt et al. 2011). Most of these studies have used surveying methods to generate descriptive statistics and test hypotheses on the adoption of a wide variety of information technologies. However, only a few studies have focused exclusively on software investments (Assadi and Sowlati 2009, Assadi et al. 2009).

As a member of the manufacturing sector, the cabinet industry (North American Industry Classification System [NAICS] 33711) is relatively small but still consequential, accounting for Can$1.3 billion in value added and providing nearly 20,000 full-time equivalent jobs in 2009 (Industry Canada 2011). The domestic market for cabinets remains strong in Canada, with 7.4 percent average annual growth from 2000 to 2009. However, the total value of shipments from Canadian cabinet manufacturers has been decreasing since 2006, due mainly to a decrease in exports to the United States. Previous research has found that IT is even more critical for exporters than it is for producers who compete in the domestic market only (Pitis and Vlosky

The authors are, respectively, Graduate Student and Associate Professor, Dept. of Wood Sci., Univ. of British Columbia, Vancouver, British Columbia, Canada (richardlhewitt@gmail.com, taraneh.sowlati@ubc.ca [corresponding author]); and Director, Centre for Management of Technol. and Entrepreneurship, Faculty of Applied Sci. and Engineering, Univ. of Toronto, Toronto, Ontario, Canada (paradi@mie.utoronto.ca). This paper was received for publication in August 2012. Article no. 12-00089.

Forest Prod. J. 62(7/8):597–606.

2000a, 2000b; Stennes et al. 2006; Arano 2008). Thus, stronger IT investments can play a significant role in regaining lost ground in exports. Given the rising importance of IT in manufacturing competitiveness and its relative underinvestment within wood products industries, it is important to investigate how to better leverage different types of software for the future competitiveness of the Canadian cabinet industry.

Commonly, IT is defined as being composed of hardware, software, and communication technologies (Merriam-Webster 2011). As hardware continues to become exponentially cheaper and faster, more companies have access to the best available hardware. Subsequently, companies have shifted more investment toward software to gain a competitive edge (Arora et al. 2010). The share of software investments in total IT investment has risen from 37.0 percent in 1981 to 66.6 percent in 2011 in Canadian manufacturing and from 38.9 percent in 1987 to 70.6 percent in 2010 in US manufacturing (CSLS 2012). To reflect this shift, this research focused on software. Previously, West and Sinclair (1992) assessed innovative technologies in the US furniture industry, but they focused more on processing technologies rather than software. Also, given the fast pace of IT, that study is dated.

Recently, research has been done on software in the Canadian cabinet industry (Assadi and Sowlati 2009, Assadi et al. 2009). However, the scope of that research was constrained to a firm-level analysis of a specific type of software (i.e., computer-aided design [CAD] and computer-aided machining [CAM]) using software-specific criteria. The present study, on the other hand, was broader in scope. It was an industry-level analysis that evaluated a wide range of business software using the competitive capabilities and strategies relevant to manufacturing as evaluation criteria.

The primary objective of this study was to determine which types of business software may contribute most to the future competitiveness of the Canadian cabinet industry. These results can provide business leaders with insight as to where they may have gaps in their overall technology portfolio or may better leverage specific types of software to achieve their strategic objectives. Also, these results augment and update a 2008 technology roadmap conducted by the Wood Manufacturing Council (WMC) in Canada (WMC 2008).

The results of this study are specific to Canada, because Canadian industry experts were surveyed and their judgements on Canada's competitive strategies were used as input for the Analytic Network Process (ANP) model. However, the ANP model itself is more general. A sensitivity analysis of the model can give insight regarding how the results change with different competitive scenarios or strategies. Thus, while the model's results are interpreted for the Canadian cabinet industry, the sensitivity analysis can be interpreted across a wide range of competitive strategies.

Materials and Methods

A wide variety of IT evaluation methods have been developed over the past three decades (Gunasekaran et al. 2006). This study used the ANP, a multicriteria decision-making (MCDM) method (Saaty 1996). MCDM methods have gained popularity among researchers and practitioners in IT evaluation for several reasons. Their flexibility in accommodating many different types of criteria into the same model makes them well-suited for the complex nature of IT investments (Salo et al. 2003). In particular, their ability to handle intangible criteria is important, because intangibles are considered to be especially crucial in these investments (Brynjolfsson and Hitt 1998). Also, the visual nature and relative simplicity of these tools allow them to be easily understood by the business community. This, in turn, enables them to be used as communication tools for shared understanding and greater transparency of the decision problem (Salo et al. 2003).

A growing body of research uses ANP for IT investment evaluation. The first application of ANP in a strategic IT decision was in developing a model to choose the best supply-chain management system (Meade and Sarkis 1998). Shortly thereafter, a more general ANP model was devised to align an organization's IT investment decisions with its business strategy (Presley and Meade 1999). Since then, ANP has had a variety of applications in IT investment evaluation across several industries. ANP models have been developed for evaluating Enterprise Resource Planning (ERP) systems for a printed circuit-board manufacturer (Shyur 2003), transaction processing systems for a university (Erdogmus et al. 2005), commercial off-the-shelf software for a consumer electronics manufacturer (Shyur 2006), Manufacturing Execution Systems for a textile manufacturer (Chao and Qing 2006), ERP systems for a semiconductor and computer technology manufacturer (Sarkis and Sundarraj 2006), general e-commerce strategy (Raisinghani et al. 2007), and technology outsourcing decisions (Tjader et al. 2009). The previous list is not intended to be exhaustive but, rather, to illustrate ANP's flexibility and usefulness in IT evaluation.

The ANP is the general form of the more commonly known Analytic Hierarchy Process (AHP). Both AHP and ANP were developed by Saaty (Saaty 1980, 1996), and both are methods of decomposing a multicriteria decision problem into its objective, criteria, and alternative components, followed by structuring the components into either a hierarchy or a network structure. The ultimate goal of both methods is to determine the best alternative for a decision.

The primary difference between AHP and ANP is that AHP assumes alternatives and criteria are independent of each other. In contrast, ANP allows interdependencies within and between the alternatives and criteria to be modeled. Due to AHP's interdependency limitations, it has been criticized by some researchers as being too simplistic for IT investment evaluation (Ncube and Dean 2002, Sarkis and Sundarraj 2006). For this reason, ANP was chosen over AHP to model the strategic software investment decision.

Both AHP and ANP are used in decisions where there are multiple criteria to evaluate multiple alternatives. The criteria and alternatives are evaluated in a pairwise fashion. When a criterion or alternative influences another criterion or alternative, an arrow is drawn to represent that relationship in ANP. Where two or more criteria or alternatives influence another criterion or alternative, a node in the ANP model is represented by a matrix. The matrix, A, is often referred to as the pairwise comparison matrix (PCM; see Eq. 1). Suppose you are evaluating n alternatives against one criterion. Then, $(w_1, \ldots, w_n)$ are the weights of alternatives 1 to n. The pairwise comparison of each alternative against the other ones with respect to the criterion is shown in Equation 1:

$$A = \begin{bmatrix} \frac{w_1}{w_1} & \cdots & \frac{w_1}{w_n} \\ \vdots & \ddots & \vdots \\ \frac{w_n}{w_1} & \cdots & \frac{w_n}{w_n} \end{bmatrix} = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \cdots & 1 \end{bmatrix} \quad (1)$$

where A is the PCM, w_1 is the weight or value for alternative 1, and n is the number of alternatives being compared in the PCM. The ratio of the weight of alternatives i and j is represented by a single number in the PCM ($a_{ij} = w_i/w_j$; Saaty 1990). In a PCM, the inverse judgment is assumed to be the reciprocal of the original judgment ($a_{ji} = 1/a_{ij}$). Also, an alternative compared with itself is equally important as itself and thus has a value of 1 ($a_{ii} = 1$).

If a PCM A is multiplied by the vector of alternative weights w, we get the equation $Aw = cw$. If c is an eigenvalue of A, then w is the eigenvector corresponding to c. It has been shown that the eigenvector representing the weights of the alternatives is the one associated with the largest eigenvalue. Therefore, the priority vector w is the principle right eigenvector of A. This priority vector is then normalized so that it sums to one (Saaty 1990).

In ANP, there will be multiple PCMs, depending on the structure of the model. To determine the final priorities of alternatives, each PCM A_{ij} is placed into the Supermatrix W (Eq. 2). Each PCM's placement into the Supermatrix is determined by how it spreads influence, as indicated by the connecting arrows in the structure. Once the Supermatrix is obtained, its Cesaro Sum is calculated until the Supermatrix converges on a unique, stable limit (Eq. 3). This lengthy process has been automated in the Super Decisions software used in this research (Adams and Saaty 2003).

$$W = \begin{bmatrix} A_{11} & A_{12} & \cdots & A_{1n} \\ A_{21} & A_{22} & \cdots & A_{21} \\ \vdots & \vdots & \ddots & \vdots \\ A_{n1} & A_{n2} & \cdots & A_{nn} \end{bmatrix} \quad (2)$$

$$\lim_{k \to \infty} \frac{1}{N} \sum_{k=1}^{N} W^k \quad (3)$$

When a stable limit is achieved, intermediate weights and final priorities can be found within the Supermatrix. In this article, ''intermediate weights'' refers to the weight of importance of each general competitive strategy and also to the relative amount that each software type contributes to each specific competitive capability. ''Final priorities'' refers to the overall relative contribution of each software type to the overall competitiveness of the industry.

Three methods are used to validate the ANP model in this study. First, the consistency ratio (CR) is a measure of the logical consistency of an individual as defined by the transitivity principle ($a_{ij} \times a_{jk} = a_{ik}$; Saaty 2005). Second, the sine of the angle between two decision maker's priority vectors is a measure of the consistency between individuals (i.e., the group's consensus; Bryson 1996). Consensus is measured by $1 - \sin(w^t, w^r)$, where w^t and w^r are the priority vectors of decision maker t and r, respectively. Thus, a value of one is considered to be perfect agreement and value of zero to be perfect disagreement. Third, a sensitivity analysis shows how robust the final priorities of the alternatives are over varying levels of weights of the criteria. This also allows the results to be interpreted for differing competitive strategies (Saaty 2005).

It should be noted that in this study, the researchers employed slight variations on the original ANP method developed by Dr. Saaty. These variations were carefully chosen, because they either improved the consistency of the model or made the survey less laborious for the decision maker. Please refer to Hewitt (2011) for a detailed description and justification of each variation on the original method.

The overall objective of the ANP model was to determine which types of business software applications would most contribute to (or enable) the future competitiveness of the Canadian cabinet industry. The alternatives were the major types of business software applications. The criteria for the model were the competitive capabilities and strategies found in manufacturing.

Extensive research has already been conducted on the different manufacturing strategies and the capabilities that contribute to each strategy. A thorough review of the literature was conducted to first identify the strategies and their associated capabilities. The *Cost* strategy is composed of the *low operating cost* capability (Gröler and Grübner 2006). The *Quality* strategy is composed of *performance quality* and *conformance quality* capabilities (Vickery et al. 1997). The *Flexibility* strategy is composed of *product flexibility, process flexibility,* and *skilled labor* capabilities (Kathuria 2000, DeLong et al. 2007). The *Delivery* strategy is composed of *delivery speed* and *delivery dependability* capabilities (Ward and Duray 2000). The *Customer Service* strategy is composed of *advertising, customer service,* and *market research* capabilities (Roth and Miller 1992, DeLong et al. 2007). The analysis was also conducted to determine the relationships between the competitive capabilities, because research shows that they do not exist in isolation (Dangayach and Deshmukh 2001). When more than one article showed evidence of a relationship between capabilities, the relationship was included in the ANP model.

Next, this study adopted the International Data Corporation (IDC) Software Taxonomy to define the major groups of business software applications (Heiman 2010). The IDC taxonomy was chosen because of the IDC's high reputation in IT industry research and the appropriateness of the taxonomy for this study. Also, the IDC claims the taxonomy is mutually exclusive, an important condition for any MCDM model (Salo et al. 2003).

The IDC Software Taxonomy separates commercial off-the-shelf business software into eight different categories based on the functionalities they contain: *Consumer, Collaboration, Content, Enterprise Resource Management* (ERM), *Supply Chain Management* (SCM), *Operations & Manufacturing, Engineering,* and *Customer Relationship Management* (CRM) applications. Consumer applications are not included in this study, because the focus here is on business applications. Additionally, Operations & Manufacturing and Engineering applications were merged into one group called *Operations & Engineering,* because the researchers deemed them to be very similar and merging the two meant a reduction in the number of pairwise comparisons required to be done by the decision makers.

For a full description of the functionalities included in each software category, please see Heiman (2010). By combining the IDC Software Taxonomy with the previous literature on manufacturing strategy, an ANP model was developed that integrates general strategies, the capabilities that comprise those strategies, and the different software types that enable those capabilities (Fig. 1).

Data for the ANP model were obtained through expert surveys. Two surveys were administered, one to each of the two expert groups involved: the technology experts and the strategy experts. The strategy expert group was composed of cabinet industry professionals and consultants. They determined the strategic priorities for the Canadian cabinet industry and the strength of relationships between different capabilities in the industry. The technology expert group was composed of IT professionals and researchers. They determined how each software type contributes to each capability. To be considered an expert for this study, a candidate needed at least 5 years of experience in the respective field.

In total, nine experts completed surveys (Table 1). To recruit experts, a list of potential experts was first compiled using recommendations from academics and professionals in the wood and IT industries. Additionally, a list of Management Information Systems (MIS) academics was gathered through searching the citation lists of the MIS literature. Because the first round of recruitment did not gather enough willing participants for the strategy group, a ''call for experts'' was posted on the Internet's largest woodworking forum (www.woodweb.com).

Because the experts were located across North America, the survey was deployed using SurveyGizmo, a Web-based surveying software (SurveyGizmo, Inc. 2011). Once the surveys were completed, the responses were transferred to Super Decisions for the ANP analysis (Adams and Saaty 2003).

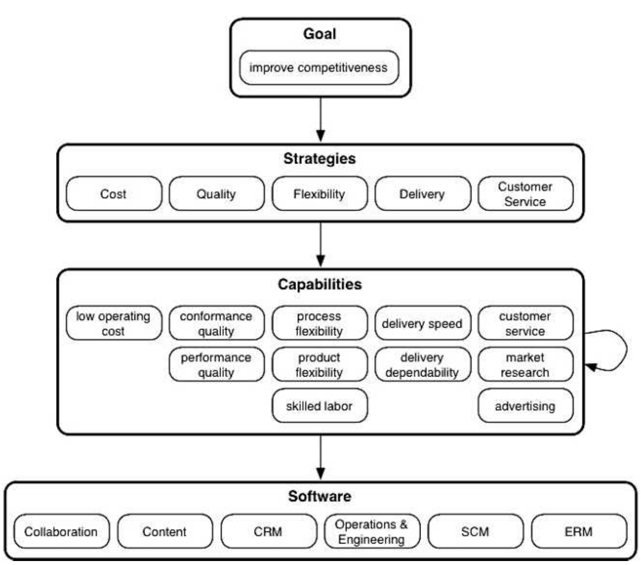

Figure 1.—The Analytic Network Process (ANP) research model. Higher levels of the hierarchy influence lower levels. A looping arrow indicates interdependencies between objects within a major level. CRM = Customer Relationship Management; SCM = Supply Chain Management; ERM = Enterprise Resource Management.

Results

Traditionally, any PCM with a CR greater than 0.10 is deemed too inconsistent and is discarded (Saaty 1980). In this study, 30 percent of the CRs were between 0.10 and 0.15. The researchers thought it was important to keep these responses to prevent making any node in the network too sensitive to an individual decision maker. For example, the product flexibility node only had one decision maker with CR < 0.10. Consequently, if the threshold were set to 0.10, this node would have been entirely biased toward one decision maker's judgments. Thus, the CR threshold was relaxed so that any PCM with a CR greater than 0.15 was discarded. In general, the experts were fairly consistent, with only 13 percent of the PCMs being discarded for having CR > 0.15. It is interesting to note that one expert (E_5) was perfectly consistent in all responses and also spent the most time completing the survey.

Consensus is given by the sine of the angle between priority vectors and was measured for the priority vectors of PCMs with CR < 0.15. The strategy group had a high level of consensus, whereas the technology group had a low consensus on how different types of software applications would contribute to each of the competitive capabilities. In fact, none of the technology comparisons achieved the 0.826 minimum consensus threshold recommended by Bryson (1996).

Intermediate weights, similar to final priorities, can be obtained from the Supermatrix once it has converged to a stable solution. A Quality strategy was determined to be the most important (0.332) for the future competitiveness of the Canadian cabinet industry, followed by a Cost strategy (0.214; Fig. 2). Customer Service and Flexibility strategies had equivalent weights (0.172), whereas a Delivery strategy had the lowest weight (0.111), for future competitiveness.

Because a Quality strategy was determined to be of such high importance, the weights of software applications contributing to performance quality and conformance quality (the competitive capabilities linked to the Quality strategy) would greatly influence the final priorities of software applications. Operations & Engineering applications had the highest contribution toward conformance quality (0.307), and ERM applications had the highest contribution toward performance quality (0.230; Fig. 3).

In the final priorities, Operations & Engineering and ERM applications were the two highest-priority application types, scoring 0.227 and 0.222, respectively (Fig. 4). Collaboration and CRM applications were tied for the third-highest priority, with a value of 0.164. SCM and Content applications had the lowest priorities, at 0.136 and 0.087, respectively.

When using ANP, it is important to do a sensitivity analysis to address expert uncertainty and see how robust the results are. Also, because this research was done with respect to the industry as a whole, the results may not be relevant to an individual firm employing a unique strategy. Using sensitivity analysis, we can determine how varying the weights of different competitive strategies will affect the final priorities of software application types; therefore, different competitive scenarios can be explored.

In the sensitivity analysis, one competitive strategy was adjusted at a time, and the relative amounts of other strategies were fixed. For example, in Figure 5, the weight of the Cost strategy (*x* axis) was allowed to vary, and the

Table 1.—Composition of expert groups.

Expert (E)	Years of experience	State/province	Occupation
Strategy group			
E_1	38	ON	Industry consultant
E_2	27	BC	Industry consultant
E_3	17	BC	Production manager
E_4	15	BC	Production manager
E_5	7	ON	Production manager
IT group			
E_6	21	BC	Professor of Management Information Systems
E_7	12	BC	Professor of Management Information Systems
E_8	12	ON	Software company president[a]
E_9	11	FL[b]	Technical manager, owner/operator

[a] Because E_8 represents a software vendor, any potential bias was tested. The final rankings of software applications did not change with E_8's responses included, so they were retained for the analysis.

[b] It is acceptable for an expert in the IT group to be outside Canada, because the software is available globally and is therefore country-independent.

resulting final priorities of the software applications (*y* axis) were given as a linear function of Cost. In the sensitivity plot, a steeper slope means that the application's final priority value is more sensitive to the weight of that particular strategy.

For the Cost, Quality, Flexibility, and Delivery strategies, ERM and Operations & Engineering applications were either the highest or second-highest priorities for all feasible weights of those strategies (Figs. 5 through 8). SCM, CRM, and Collaboration applications alternated between the third-, fourth-, and fifth-highest priorities. Content applications consistently had the lowest priority.

This pattern did not hold for varying weights of the Customer Service strategy (Fig. 9). An increasing emphasis on this strategy yielded highest priorities for CRM and Collaboration applications. The sensitivity plot clearly shows that the final rankings of applications changed frequently, and the slopes of the lines are steeper than those in the other plots. Thus, the final priority vector was most sensitive to the weighting of the Customer Service strategy.

Discussion

The consensus measures yielded mixed results with regards to the level of agreement between experts. The strategy group (cabinet industry) experts largely agreed on the strength of relationships for conformance quality, process flexibility, and customer service. This may indicate a common understanding in the industry as to how these competitive capabilities influence each other. For example, the experts had consensus on the relative amounts that delivery speed and conformance quality affect process flexibility. On the other hand, a low level of consensus was found in the technology group (IT professionals) with respect to how different software applications contribute to each competitive capability. This could be due to a number of reasons. First, each expert's professional background could greatly influence that expert's perception of how IT can serve businesses and introduce bias toward particular types of software. Additionally, it is possible that each expert had a slightly different personal definition of each application type. Explicit definitions of the applications were included with the survey, and it was strongly recommended to use those definitions while taking the survey. However, it is possible that the experts did not carefully examine these definitions when responding.

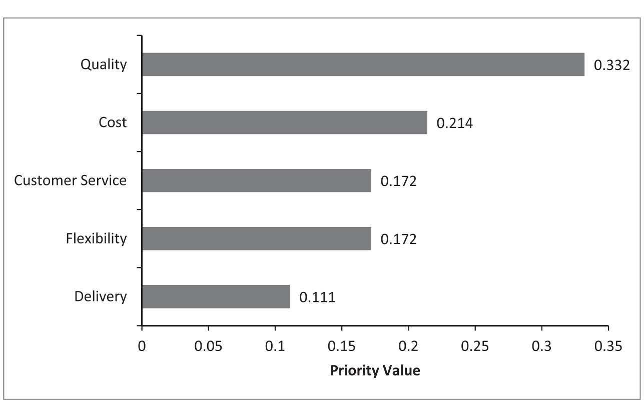

Figure 2.—Intermediate weights for general competitive strategies.

An emphasis on a Quality strategy (0.332) over a Cost strategy (0.214) is largely in accordance with the results of a study of leading North American and European value-added wood products firms (Korhonen and Niemelä 2004). That study concluded that whereas low cost is necessary to compete in the industry, it is not enough for a sustainable competitive advantage. A Delivery strategy scored the lowest or second lowest for all but one strategy group expert. This level of agreement is encouraging, because a 2006 study of Canadian value-added wood manufacturers found that an emphasis on quick delivery can have significant negative effects on a firm's profitability (DeLong et al. 2007).

Customer Service (0.712) and Flexibility (0.712) strategies were rated as equally important overall (Fig. 2). Previous research has suggested that marketing is especially crucial for small- and medium-sized secondary US wood manufacturers (Hoff et al. 1997), and customer service and marketing are areas where improvement can be made for Canadian wood manufacturers (DeLong et al. 2007). In the furniture industry, which is similar to the cabinet industry, innovation is a key order winner (Vickery et al. 1997). Innovation is encapsulated by the Flexibility strategy, specifically the product flexibility capability (Kathuria 2000).

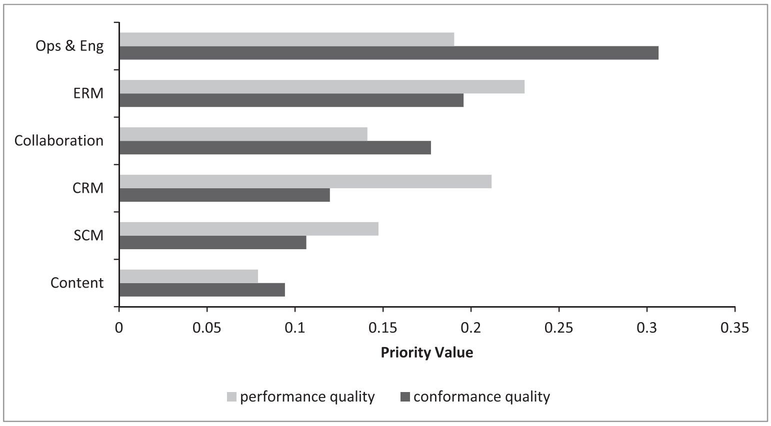

Figure 3.—Intermediate weights of software contributions toward performance quality and conformance quality, the two capabilities comprising the Quality strategy. Ops & Eng = Operations & Engineering; ERM = Enterprise Resource Management; CRM = Customer Relationship Management; SCM = Supply Chain Management.

It is not surprising that Operations & Engineering applications had the highest overall priority (0.227; Fig. 4), because software in this category addresses design and production, which are everyday activities in the cabinet industry. The most common uses of software in this application category were parametric design, CAD, CAM, panel optimization/nesting, and bill-of-materials generation. In fact, these business functions were some of the earliest applications of IT in a plant setting (Ake and Cubine 2004).

The ERM software was given a high final priority (0.222; Fig. 4), most likely because it often addresses administrative activities (e.g., accounting and payroll) that are essential to most businesses, regardless of industry. Order management is another function under the ERM category that can be especially useful in the cabinet industry. One of the experts surveyed, a highly experienced industry consultant who has worked with numerous cabinet firms around the world, spoke at length about several clients having difficulties with product and order configuration. These issues arise because cabinetry often has many customizable options that result in thousands of possible product variations. Applications having order management functionality address this challenge. The potential of software to solve configuration and ordering problems has also been highlighted in a recent industry technology roadmap done by Canadian government's WMC (WMC 2008).

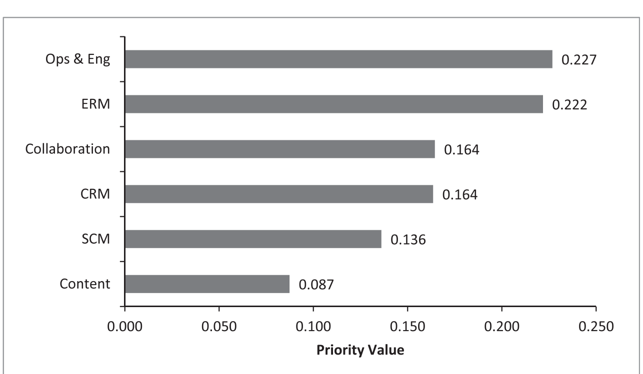

Figure 4.—Final priorities of software applications. Abbreviations are explained in the legend for Figure 3.

Content applications had the lowest priority (0.087; Fig. 4), because their contribution was the lowest or second lowest for all capabilities except advertising. Given that this industry is very product oriented, it is expected that Content applications will have little influence on the industry's competitiveness. However, previous research has observed a slow shift in wood products industries from a strictly product orientation toward a more marketing orientation (Cohen and Kozak 2002). If this evolution continues, it could mean that Content applications will be more important in the future, because providing excellent online experiences and informational resources is becoming increasingly critical for effective Web-based marketing and e-commerce (Hausman and Siekpe 2009)

The results of the sensitivity analysis reveal that regardless of an individual expert's weighting of Cost, Quality, Flexibility, and Delivery strategies, Operations & Engineering and ERM applications have the highest and second-highest priority, and Content applications have the least importance to the industry's competitiveness (Figs. 5 through 8). However, the priorities of SCM, CRM, and Collaboration applications will vary between the third- and fifth-highest priorities, depending on the weighting of strategies. Thus, for every strategy except Customer Service, there are three groups of applications with decreasing levels of strategic importance: Operations & Engineering and ERM (high importance); SCM, CRM, and Collaboration (medium importance); and Content (low importance).

The final priorities of the model are most sensitive to the Customer Service strategy. Thus, a company that places a high emphasis on customer service will likely have very different final priorities for software applications. In this case, CRM and Collaboration applications become more important than Operations & Engineering and ERM applications (Fig. 9), because the latter are more closely aligned with the Quality strategy (Fig. 3). However, it is possible that Customer Service is dependent on first achieving the Quality strategy. Ferdows and De Meyer's (1990) famous sand cone model was one of the first studies to thoroughly explore the theory that Quality is the initial foundation upon which success in other strategies is built. Empirical studies have also supported the possible existence of dependency in manufacturing strategy (Gröler and

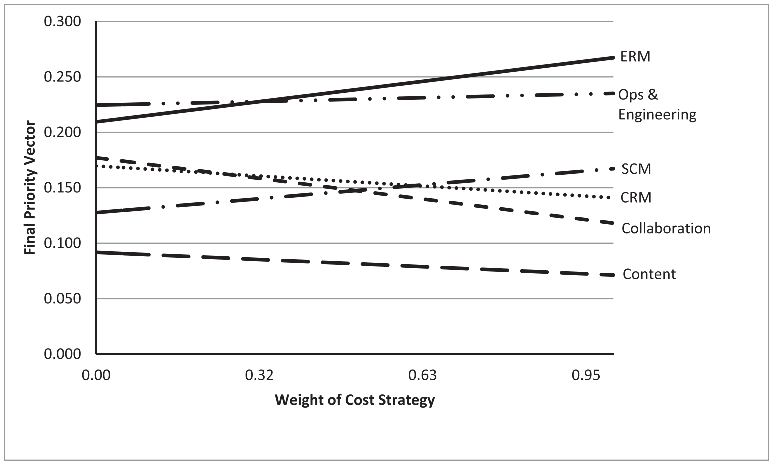

Figure 5.—Sensitivity analysis showing the effect of varying weights of the Cost strategy on final priorities of software applications. Abbreviations are explained in the legend for Figure 3.

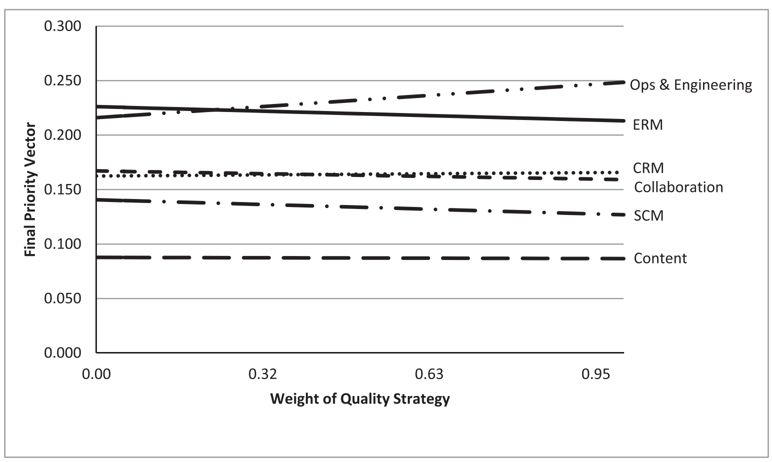

Figure 6.—Sensitivity analysis showing the effect of varying weights of the Quality strategy on final priorities of software applications. Abbreviations are explained in the legend for Figure 3.

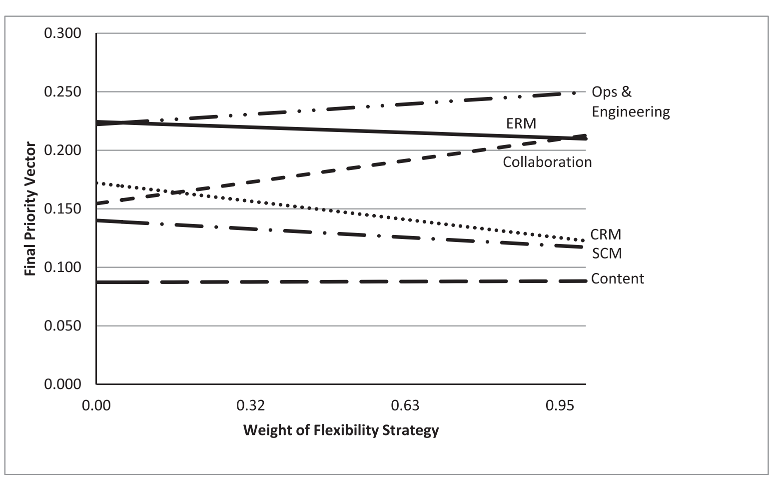

Figure 7.—Sensitivity analysis showing the effect of varying weights of the Flexibility strategy on final priorities of software applications. Abbreviations are explained in the legend for Figure 3.

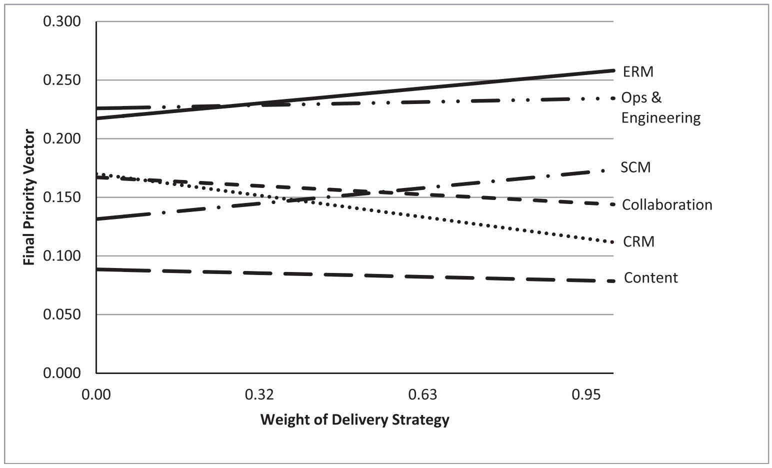

Figure 8.—Sensitivity analysis showing the effect of varying weights of the Delivery strategy on final priorities of software applications. Abbreviations are explained in the legend for Figure 3.

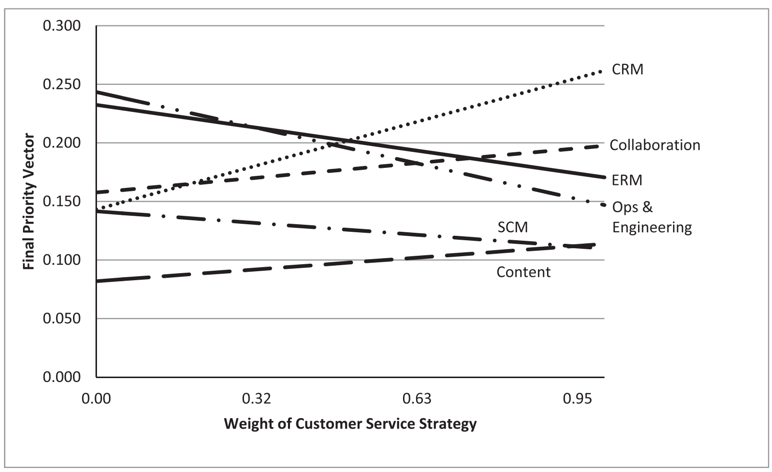

Figure 9.—Sensitivity analysis showing the effect of varying weights of the Customer Service strategy on final priorities of software applications. Abbreviations are explained in the legend for Figure 3.

Grübner 2006). Integrating dependencies of strategies into this model based on previous work could provide interesting opportunities for future research.

It is important to recognize the limitations of having only nine experts as input into the model. The low number of experts makes the model sensitive to personal bias. As such, the specific results should be regarded with a fair amount of caution. However, interesting insights can be gained by looking at relative amounts. Additionally, the ANP model itself is useful, because it represents a way of thinking about how software affects competitive strategies in the cabinet industry.

Conclusions

A Quality strategy is the most important for the future overall competitiveness of the Canadian cabinet industry, with an intermediate weight of 0.332. This agrees with previous literature concerning the wood products industries (Korhonen and Niemelä 2004) and also general manufacturing strategy theory (Ferdows and De Meyer 1990). Delivery is the least important strategy (0.111), which agrees with a study by DeLong et al. (2007) of Canadian secondary wood manufacturers.

For final priorities of software, Operations & Engineering (0.227) and ERM (0.222) applications have the highest contribution to overall competitiveness. This is because of their high contribution toward capabilities comprising the crucial Quality strategy and their everyday role in administration and production activities. Content applications are the least important for future competitiveness (0.087). This is not surprising given the product orientation of the industry; however, this could become more important as Web-based marketing and e-commerce continue to rise in significance.

The sensitivity analysis shows how the final priorities of software change with varying weights of strategies. The analysis indicates that the final priorities of software are robust for all strategies except Customer Service. Operations & Engineering and ERM applications are the first or second priority; SCM, CRM, and Collaboration switch between the third, fourth, and fifth priorities; and Content is generally the lowest priority. However, the results are most sensitive to the weight of the Customer Service strategy.

Literature Cited

Adams, W. J. L. and R. W. Saaty. 2003. Super Decisions Software Guide. http://www.ii.spb.ru/admin/docs/SuperDecisionsHelp2011.pdf. Accessed February 4, 2013.

Ake, K. and M. Cubine. 2004. Information Technology for Manufacturing: Reducing Costs and Expanding Capabilities. CRC Press, Boca Raton, Florida.

Arano, K. G. 2008. Electronic commerce adoption in West Virginia's primary and secondary hardwood industries: Preliminary results. *In:* Center for Forest Business Publication No. 30, Proceedings of the 2008 Southern Forest Economics Workers Annual Meeting, J. Siry, B. Izlar, P. Bettinger, T. Harris, T. Tye, S. Baldwin, and K. Merry (Eds.), March 9–11, 2008, Savannah, Georgia; Center for Forest Business, Warnell School of Forestry and Natural Resources, University of Georgia. pp. 72–81.

Arora, A., L. G. Branstetter, and M. Drev. 2010. Going soft: How the rise of software based innovation led to the decline of Japan's IT industry and the resurgence of Silicon Valley. www.nber.org/papers/w16156. Accessed February 4, 2013.

Assadi, P. and T. Sowlati. 2009. Design and manufacturing software selection in the wood industry using analytic hierarchy process. *Int. J. Bus. Innov. Res.* 3(2):182–198.

Assadi, P., T. Sowlati, and J. C. Paradi. 2009. Multi-criteria evaluation of design and manufacturing software packages considering the interdependencies among criteria: The analytic network process approach. *Int. J. Inf. Decision Sci.* 1(4):397–410.

Atrostic, B. and J. Gates. 2001. US productivity and electronic business processes in manufacturing. http://ideas.repec.org/p/cen/wpaper/01–11.html. Accessed February 4, 2013.

Baldwin, J. R. and D. Sabourin. 2001. Impact of the adoption of advanced information and communication technologies on firm performance in the Canadian manufacturing sector. Analytical Studies Branch, Statistics Canada, Ottawa.

Bartel, A. P., C. Ichniowski, and K. L. Shaw. 2005. How does information technology really affect productivity? Plant-level comparisons of product innovation, process improvement and worker skills. www.nber.org/papers/w11773. Accessed February 4, 2013.

Brynjolfsson, E. and L. M. Hitt. 1998. Beyond the productivity paradox. *Commun. ACM* 41(8):49–55.

Bryson, N. 1996. Group decision-making and the analytic hierarchy process: Exploring the consensus-relevant information content. *Comput. Oper. Res.* 23(1):27–35.

Centre for the Study of Living Standards (CSLS). 2012. Database of information and communication technology (ICT) investment and capital stock trends: Canada vs United States. CSLS, Ottawa. http://www.csls.ca/data/ict.asp. Accessed February 4, 2013.

Chao, L. and L. Qing. 2006. Manufacturing Execution Systems (MES) assessment and investment decision study. *In:* IEEE International Conference on Systems, Man and Cybernetics, October 8–11, 2006, Taipei, Taiwan. pp. 5285–5290.

Cohen, D. H. and R. A. Kozak. 2002. Research and technology: Market-driven innovation in the twenty-first century. *Forestry Chron.* 78(1):108–111.

Dangayach, G. S. and S. G. Deshmukh. 2001. Manufacturing strategy: Literature review and some issues. *Int. J. Oper. Prod. Manag.* 21(7):884–932.

DeLong, D. L., R. A. Kozak, and D. H. Cohen. 2007. Overview of the Canadian value-added wood products sector and the competitive factors that contribute to its success. *Can. J. Forest Res./Rev. Can. De Rech. Forestiere* 37(11):2211–2226.

Erdogmus, S., M. Kapanoglu, and E. Koē. 2005. Evaluating high-tech alternatives by using analytic network process with BOCR and multiactors. *Eval. Program Plann.* 28(4):391–399.

Ferdows, K. and A. De Meyer. 1990. Lasting improvements in manufacturing performance: In search of a new theory. *J. Oper. Manag.* 9(2):168–184.

Gröler, A. and A. Grübner. 2006. An empirical model of the relationships between manufacturing capabilities. *Int. J. Oper. Prod. Manag.* 26(5):458–485.

Gunasekaran, A., E. Ngai, and R. McGaughey. 2006. Information technology and systems justification: A review for research and applications. *Eur. J. Oper. Res.* 173(3):957–983.

Hausman, A. V. and J. S. Siekpe. 2009. The effect of web interface features on consumer online purchase intentions. *J. Bus. Res.* 62(1):5–13.

Heiman, R. 2010. IDC's software taxonomy, 2010. http://www.idc.com/research/viewtoc.jsp?containerId=222023. Accessed February 4, 2013.

Hewitt, R. 2011. Evaluation of strategic software investments for the Canadian cabinet industry. University of British Columbia, Vancouver. https://circle.ubc.ca/handle/2429/40368. Accessed February 4, 2013.

Hewitt, R., T. Sowlati, and J. C. Paradi. 2011. Information technology adoption in US and Canadian forest products industries. *Forest Prod. J.* 61(2):161–169.

Hoff, K., N. Fisher, S. Miller, and A. Webb. 1997. Sources of competitiveness for secondary wood products firms: A review of literature and research issues. *Forest Prod. J.* 47(2):31–37.

Industry Canada. 2011. Canadian industry statistics—Data tables. http://www.ic.gc.ca/cis-sic/cis-sic.nsf/IDE/cis-sic31-33tabe.html. Accessed September 27, 2011.

Kathuria, R. 2000. Competitive priorities and managerial performance: A taxonomy of small manufacturers. *J. Oper. Manag.* 18(6):627–641.

Korhonen, S. and J. S. Niemelä. 2004. Guidelines for sustainable, external corporate growth: A case study of the leading European and North American companies in the wood industry. *J. Forest Prod. Bus. Res.* 1(2):1–27.

Meade, L. and J. Sarkis. 1998. Strategic analysis of logistics and supply chain management systems using the analytical network process. *Transp. Res. Part E Logist. Transp. Rev.* 34(3):201–215.

Merriam-Webster. 2011. Information technology. http://www.merriam-webster.com/dictionary/informationtechnology. Accessed February 4, 2013.

Ncube, C. and J. Dean. 2002. The limitations of current decision-making techniques in the procurement of COTS software components. *In:* Proceedings of the 1st International Conference on COTS-Based Software System, February 4–6, 2002, Orlando, Florida. pp. 176–187.

Pitis, O. and R. Vlosky. 2000a. Web presence of US primary wood products exporters. *Forest Prod. J.* 50(7–8):55–58.

Pitis, O. T. and R. P. Vlosky. 2000b. Forest products exporting and the Internet: Current use figures and implementation issues. *Forest Prod. J.* 50(10):23–29.

Presley, A. and L. Meade. 1999. Strategic alignment and IT investment selection using the analytic network process. *In:* Americas Conference on Information Systems (AMCIS) 1999 Proceedings. pp. 411–413. http://aisel.aisnet.org/cgi/viewcontent.cgi?article=1500&context=amcis1999. Accessed February 4, 2013.

Raisinghani, M. S., L. Meade, and L. L. Schkade. 2007. Strategic e-business decision analysis using the analytic network process. *IEEE Trans. Eng. Manag.* 54(4):673–686.

Roth, A. V. and J. G. Miller. 1992. Success factors in manufacturing. *Bus. Horiz.* 35(4):73–81.

Saaty, T. L. 1980. The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation. McGraw-Hill, New York.

Saaty, T. L. 1990. How to make a decision: The analytic hierarchy process. *Eur. J. Oper. Res.* 48:9–26.

Saaty, T. L. 1996. Decision Making with Dependence and Feedback: The Analytic Network Process, the Organization and Prioritization of Complexity. RWS Publications, Pittsburgh, Pennsylvania.

Saaty, T. L. 2005. Theory and Applications of the Analytical Network Process: Decision Making with Benefits, Opportunities, Costs, and Risks. RWS Publications, Pittsburgh, Pennsylvania.

Salo, A., T. Gustafsson, and R. Ramanathan. 2003. Multicriteria methods for technology foresight. *J. Forecast.* 22(2–3):235–255.

Sarkis, J. and R. P. Sundarraj. 2006. Evaluation of enterprise information technologies: A decision model for high-level consideration of strategic and operational issues. *IEEE Trans. Syst. Man Cybern. C Appl. Rev.* 36(2):260–273.

Shyur, H. J. 2003. A semi-structured process for ERP systems evaluation: Applying analytic network process. *J. e-Bus.* 5(1):33–49.

Shyur, H. J. 2006. COTS evaluation using modified TOPSIS and ANP. *Appl. Math. Comput.* 177(1):251–259.

Stennes, B., C. Stonestreet, B. Wilson, and S. Wang. 2006. e-Technology adoption by value added wood processors in British Columbia. *Forest Prod. J.* 56(5):24–28.

SurveyGizmo, Inc. 2011. SurveyGizmo. http://www.surveygizmo.com. Accessed February 4, 2013.

Tjader, Y., J. Shang, L. Vargas, and J. May. 2009. Integrating the analytic network process and the balanced scorecard for strategic it outsourcing decision making. *In:* Proceedings of the 10th International Symposium on the Analytic Hierarchy/Network Process, July 29–August 1, 2009, Pittsburgh, Pennsylvania. pp. 1–15. http://www.isahp.org/2009Proceedings/Final_Papers/86_Tjader_Shang_Vargas_May_ANP_BalancedScorecard_for_ITDecisions_REV_FIN.pdf. Accessed February 4, 2013.

Vickery, S. K., C. Dröge, and R. E. Markland. 1997. Dimensions of manufacturing strength in the furniture industry. *J. Oper. Manag*. 15(4):317–330.

Ward, P. T. and R. Duray. 2000. Manufacturing strategy in context: Environment, competitive strategy and manufacturing strategy. *J. Oper. Manag*. 18(2):123–128.

West, C. D. and S. A. Sinclair. 1992. A measure of innovativeness for a sample of firms in the wood household furniture industry. *Forest Sci*. 38(3):509–524.

Wood Manufacturing Council (WMC). 2008. Advanced wood processing skills and technology roadmap. Wood Manufacturing Council. http://www.wmc-cfb.ca/pdfs/advanced-wood-processing-skills-technology-roadmap.pdf. Accessed February 4, 2013.