DEVELOPING DECISION SUPPORT MODELS FOR PARTNERSHIP EVALUATION IN THE FOREST PRODUCTS SUPPLY CHAIN

by

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Abstract

The forest sector in Canada has been losing its competitiveness due to globalization and rapid change in technology. Partnership is one of the strategies that could help companies remain competitive; however, partnership is costly and has a high failure rate, according to the literature. Therefore, it is essential to monitor the performance of a partnership and evaluate the factors that affect its performance. Previous studies reveal that the performance of an ongoing partnership is influenced directly by a number of components, which are joint decision-making, information sharing, risk/reward sharing and relationship-specific assets. However, there is a gap for a comprehensive study that investigates partnerships and their components in the forest industry. In this study, first a survey is conducted from the forest companies in British Columbia, Canada, to investigate existing and potential partnerships and the factors that influence the performance of existing ones. The respondents are asked to subjectively evaluate partnership performance and the influencing factors using the Likert scale. The results of regression analysis indicate the degree of joint decision-making, relationship-specific assets, and risk/reward sharing as the best predictors of the performance of the surveyed companies. Then, two multi-criteria decision support models are developed to evaluate partnership performance and components quantitatively. Multiple quantitative criteria are used in the models. Interpretive Structural Modeling (ISM) and Analytic Network Process (ANP) are used in order to address the interdependency and the importance of criteria, respectively. Fuzzy Logic (FL) is used to capture the uncertainty in the criteria for evaluating partnership performance. The outputs of these two models are the importance of the criteria and two single numbers for the overall partnership performance and components in each period, named as Partnership Performance Index (PPI) and Partnership Component Index (PCI). The proposed models are applied to a partnership between

a logging company and a sawmill in Canada, to find PPIs and PCIs in three different periods. The rankings of the criteria from the models are compared to the ones estimated by the managers, and the results show the rankings are compatible. The results are assessed by sensitivity analysis and validated by the managers.

Preface

This dissertation is original and presents the work of Mehdi Piltan during his Ph.D. program in the Industrial Engineering Research Group at the University of British Columbia. The research was conducted by the author under the supervision of her academic adviser, Dr. Taraneh Sowlati. Dr. Sowlati advised Piltan during the process of defining the research problem, gathering data, developing and validating the models and preparing manuscripts.

This thesis presents a background on the research topic, a review of the literature, a survey of forest industry in British Columbia and two multi-criteria decision support models with their application to a real case study in Canada. The author visited the case study companies several times, had close collaboration with the managers of both companies, obtained information and detailed data on their business performance from 2011-2014, presented the model results to the managers and had the model validated by them. The survey reported in Chapters 3 was approved by the University of British Columbia's Research Ethics Board [certificate # H13-02142]. Four scientific papers and one magazine article were generated from this research, and in all of them Mehdi Piltan was the first author. The list of papers generated from this research is provided below.

1. A version of Chapter 1 is published. Piltan, M., Sowlati, T. A successful partnership for getting more value from the forest. Branchlines Magazine, 24 (4): 6-7, 2014.
2. A version of Chapter 2 is published. M. Piltan and T. Sowlati, A review of partnership studies in the forest products supply chain: With a focus on developed countries (US, Canada and Western Europe), Forest Products Journal, 64 (1), 4-10. 2014.
3. A version of Chapter 3 is accepted. Piltan, M., Sowlati, T., Cohen, D., Kozak, R., Gaston, C., Analysis of the drivers and factors influencing the performance of partnerships in

British Columbia's forest products supply chain. The Journal of Science and Technology for Forest Products and Processes, 2015.

4. A version of Chapter 4 is published. Piltan, M., Sowlati, T., A multi-criteria decision support model for evaluating the performance of partnerships, Expert Systems with Applications, Volume 45, Pages 373-384, 2016.
5. A version of Chapter 5 is under revision. Piltan, M., Sowlati, T., Multi-criteria assessment of partnership components.

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Glossary

Partnership: a collaborative business relationship with an independent company, characterized by resources, information, and risks/rewards sharing, and joint planning. Long-term relationships with fixed contracts, and mergers and acquisitions are not considered as partnership (Lambert et al., 1996).

Drivers: compelling reasons for entering into partnerships (Lambert et al., 1996).

Facilitators: existing factors that contribute to the growth and success of a partnership, these factors cannot be changed in a short period of time (Lambert et al., 1996).

Components: joint-activities and processes performed by partners in order to maintain and improve an ongoing partnership (Lambert et al., 1996).

Partnership performance: the extent to which partners have achieved their drivers for entering into a partnership (Lambert et al., 1996).

Performance measures: quantitative measures that show the performance of a partnership (Gunasekaran and Kobu, 2007).

Component indicators: quantitative indicators that show the level of a component (Arshinder et al., 2008).

Symmetry: similarity between partners in different aspects such as the size of market share in their respective sector, reputation and technological sophistication (Lambert et al., 1996).

Mutuality: mutual perspective about their partnership, such as the level of the partnership, its time horizon and their expectations (Lambert et al., 1996).

Compatibility: compatibility of partners such as their complimentary resources, core values and organizational structure (Lambert et al., 1996).

Trust: the confidence and willingness of the partners to rely on the promises and actions of each other (Moorman et al., 1993).

Commitment: partners' belief about the importance of an ongoing partnership and their willingness to invest resources to maintain and improve it (Morgan and Hunt, 1994).

Information sharing: the formal and informal sharing of relevant, reliable and timely information between partners which is characterized by content, reliability, accuracy and frequency of information (Arshinder et al., 2008).

Joint decision-making: joint planning which ranges from operational to strategic planning (Arshinder et al., 2008).

Risk/reward sharing: the processes for aligning partners' incentives by sharing costs, risks, and rewards in the form of contracts and agreements (Lambert et al., 1996).

Relationship-specific assets: dedicated assets to a specific relationship, whose redeployment entails considerable switching costs (Arshinder et al., 2008).

Likert scale: a measurement scale that is used to gauge attitudes, values, and opinions. It functions by having a person complete a questionnaire that requires them to indicate the extent to which they agree or disagree with a series of statements (Likert, 1932).

Commodity: a basic good used in commerce that is interchangeable with other commodities of the same type. Commodities are often used as inputs in the production of other goods or services.

Primary sector: comprised of companies that harvest, transport, and perform the initial processing of logs.

Secondary sector: includes companies that further add value to wood by drying, cutting and assembling wood products into parts or finished products.

Partnership Performance Index (PPI): a single and multi-dimensional index developed in this study that includes the importance, the interdependencies and the uncertainties of the performance measures and shows the overall partnership performance in each period.

Partnership Component Index (PCI): a single and multi-dimensional index developed in this study that includes the importance and the interdependencies of partnerships components and shows the overall level of partnership components in each period.

Multiple-Criteria Decision-Making (MCDM): a sub-discipline of operations research that is used when multiple (conflicting) criteria need to be evaluated in making decisions.

Interpretive Structural Modeling (ISM): an algebraic technique for analyzing interdependencies among variables (Thakkar et al., 2006).

Analytic Network Process (ANP): a multi-criteria decision analysis method that captures the interdependencies of variables in the model using a network structure. It uses a system of pairwise comparisons to estimate the weight of the variables (Saaty, 1996).

Transaction Cost Economics (TCE): a theory that suggests an inter-firm relationship which minimizes the sum of fixed and continual transaction costs (Geyskens et al., 2006).

Resource-based View (RbV): a theory that defines company's assets as the primary input for the overall strategic planning, emphasizing the way in which competitive advantage can be derived via core competency resource (Barney, 1991).

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Last but not the least, I would like to thank my family: my parents and my brothers for supporting me throughout my PhD study.

Dedication

To my mother, father and two brothers for their unconditional and unceasing love and support.

Chapter 1: Introduction

1.1 Background

The Canadian forest products industry has been losing its competitiveness due to globalization, higher customer expectations, fewer natural resources, and rapid change in technologies and markets (Sathre and Gustavsson, 2009). There have been 86,900 job losses in the forest industry since 2006 (FPAC, 2015a). The contribution of forest products to the Canadian gross domestic product fell from 2.7% to 1.25% from 2002 to 2013 (FPAC, 2015a).

1.1.1 Literature review

Relying on a few markets with limited commodity products has been challenging for the Canadian forest product industry (Bull and Williams, 2006).. Bleached softwood Kraft pulp, newsprint and softwood lumber accounted for approximately 47% of the Canadian forest product export value and the U.S. was the single largest export market (accounted for 65% share) for the Canadian forest products in 2011 (NRC, 2012). The demand for newsprint in North America has decreased more than 65% since 2000, putting extra pressure on the Canadian forest industry as the biggest newsprint producer in North America (Lucintel, 2012). High costs of the Canadian forest product sector compared to those of new competitors in lower cost environments, such as Brazil, is another challenge (Bull and Williams, 2006).

Meanwhile, new opportunities have emerged for the Canadian forest product industry. The second phase of the Bio-pathways Project, which was released in 2011 by the Forest Products Association of Canada (FPAC, 2011) and FPInnovations, estimated a potential $200 billion emerging global market for bio-products (FPAC, 2011a). The global demand for paper, especially in the emerging Asian economies, is increasing. The global paper industry experienced

stable growth over the last decade and is expected to continue its growth, reaching approximately US $256 billion in 2017 with an average growth of 5.9% from 2012 to 2017 (Lucintel, 2012).

In this new business environment for the forest industry, the main strategies to seize the opportunities and remain competitive include: 1) developing new value added products (Chambost et al., 2009; FPAC, 2011b; Hansda, 2009; Sathre and Gustavsson, 2009), 2) entering into new markets (Ambus et al., 2007; DeLong et al., 2007; Edgington, 2004), 3) diversifying product portfolio (Kozak and Maness, 2005; Sathre and Gustavsson, 2009), and 4) implementing more efficient business models and practices (DeLong et al., 2007).

A forest product company may have the required resources (capital, technology, skills and knowledge) and risk tolerance to implement the new strategies or may acquire the resources through an inter-firm relationship. Inter-firm relationships vary in intensity and range from transactional (market) to integrated (mergers and acquisitions) relationships, while partnerships fall in between these two extremes (Webster, 1992; Lambert et al., 1996; Daugherty, 2011). Partnership is an inter-firm relationship which is characterized by asset, information and risk/reward sharing, and joint decision-making (Webster, 1992; Lambert et al., 1996; Daugherty, 2011). Partnership has the potential to improve the performance of companies. It helps firms gain access to new technologies or markets, provide new products or services, gain economies of scale, have access to knowledge and skills, and share risks (Lambert et al., 1996). Because of the potential opportunities, the number of partnerships grew by almost 25% a year in the USA from 1997 to 2007 and those partnerships contributed to nearly a third of revenues earned by partners (Hughes and Weiss, 2007).

The partnership development process includes four main stages: (1) assessing the drivers/needs for partnership, (2) selecting a partner, (3) establishing the right level of

partnership, and (4) maintaining/evaluating the ongoing partnership (Ellram 1991, Hoffmann and Schlosser 2001, Kim et al. 2010). There are different drivers for entering into a partnership. Drivers are compelling reasons for entering into a partnership (Lambert et al., 1996). The most common drivers are cost reduction, customer service improvement, marketing, product development, product diversification and joint investment (Ellram, 1995; Lambert et al., 1996; Hoffmann and Schlosser, 2001; Cruijssen et al., 2007). There may be more than one driver for each partner with different importance.

Partnerships require intensive time and effort, reduce autonomy, and can result in more complexity and opportunistic behavior because of information asymmetry (Kwon and Suh, 2005). Previous studies have revealed a high failure rate (40% to 70%) for partnerships (Das and Teng, 2000). The lack of a systematic approach to evaluate potential partners and partnership have been identified among the main reasons for partnership failures (Hoffmann and Schlosser, 2001; Holmberg and Cummings, 2009). Evaluating partnerships includes evaluating partnership performance and the factors influencing the performance. The performance of a partnership can be defined as the extent to which partners achieved their objectives (their drivers for entering into partnership).

Transaction Cost Economics (TCE), Resource-based View (RbV) and Sociological theories (Soc.) are widely cited theoretical approaches for explaining the factors that influence partnership performance (Combs and Ketchen, 1999; Hoffmann and Schlosser, 2001; Markus, 2004; Geyskens et al., 2006). Based on these theories symmetry (Brinkerhoff, 2002), compatibility (Maheshwari et al., 2006), mutuality (Hoffmann and Schlosser, 2001), joint decision-making (Mohr and Spekman, 1994), relationship-specific assets (Dyer, 1996), information sharing (Hua and Cong, 2011), risk/reward sharing (Poppo and Zenger, 2002), trust and commitment (Morgan

and Hunt, 1994) are identified as the major factors affecting partnership performance. These factors can further be categorized into facilitators and components (Lambert et al., 1996). Facilitators, which include symmetry, compatibility and mutuality, are existing factors that contribute to the growth and success of a partnership but cannot be changed in a short period of time (Lambert et al., 1996). The remaining factors are the components in a partnership that can be defined and changed by joint-activities and processes performed by partners in order to maintain and improve an ongoing partnership.

The factors influencing partnership performance are very similar, however these factors have different importance in different industries (De Boer et al., 2001). These factors have been studied in several industries, such as electronics (Mohr and Spekman, 1994), retail (Sodhi and Son, 2009), and auto (KPMG International, 2012) industries, but there are a few studies in forest industry to investigate these factors and their importance. The potential benefits (e.g. Janssen et al., 2008; Frisk et al., 2010; FPAC, 2011a) and attributes of partnerships compared to typical business relationships (e.g. Wilson and Vlosky, 1997; Karuranga et al., 2008; Lefaix-Durand and Kozak, 2009; Dasmohapatra and Gonzalez, 2010) in forest industry were investigated in several studies. However, there is a gap for studies on the types of partners, partnership drivers and the importance of the factors influencing partnership performance in the forest products supply chain. The findings of this type of study could help managers establish new partnerships or revise their existing ones.

In several previous studies (e.g. Wilson, 1995; Glaister and Buckley, 1998; Hoffmann and Schlosser, 2001) a single criterion was used to evaluate the partnership performance. The single criterion was based on managers' satisfaction and their perception on achieving the overall partnership driver, which could be biased and could result in a hard to interpret evaluation

measure (Carter et al., 2007). In addition, using one or even several criteria independently (e.g. Vereecke and Muylle, 2006; Ryu et al., 2009; Rezaei et al., 2015) cannot capture the overall partnership performance. In order to comprehensively evaluate partnership performance, the drivers, as well as their relevant measures and importance must be considered in the analysis (Lambert et al., 1996). It is important to note that 1) the importance of these criteria may not be the same for each partner (Lambert et al., 1996), 2) some of the criteria may be interrelated (Verdecho et al., 2012), and 3) some criteria may be hard to estimate quantitatively (Wang and Shu, 2005). Therefore, a Multi-Criteria Decision-making (MCDM) approach is needed for evaluation of an ongoing partnership. Lambert (1997) and Simatupang and Sridharan (2005) developed a multi-dimensional index for the establishment and maintenance stages, respectively. However, the importance and the interdependencies of the measures were not considered. Lefaix-Durand et al. (2009) developed a relationship value measurement using a weighted sum of benefit and cost reduction measures generated in the relationship using seven-point continuous interval scales. Recently, Chen and Wu (2010) and Verdecho et al. (2012) incorporated the importance and interdependences of the measures. However, they did not evaluate partnership in different periods and did not consider different drivers of entering into partnerships.

Similar to partnership performance evaluation, a single measure study is not suitable for evaluating partnership components because it would not capture all the factors. Therefore, some authors used multiple indicators to study partnership components (e.g. Lambert et al., 1996; Simatupang and Sridharan, 2005). Lambert et al. (1996) suggested a scoring index based on multiple drivers to identify the appropriate level and time horizon of a partnership (short or long term) and then determined the required level of the components according to the time horizon of the partnership. Simatupang and Sridharan (2005) proposed a multi-dimensional index, named

as collaboration index, for estimating the level of partnership components. The multi-dimensional indices developed by Lambert (1997) and Simatupang and Sridharan (2005) did not incorporate the importance and the interdependencies of the indicators. Based on the three review studies in partnership area (Min and Zhou, 2002; Arshinder et al., 2008; Daugherty, 2011), the number of studies on partnership components has been increasing, however, relatively few studies assessed all the components of an existing partnership because of several difficulties. First, these components are often qualitative and hard to measure. Second, there are multiple indicators for the components which might be interdependent. Finally, the importance of each component and indicator could be different in each partnership. Arshinder et al. (2008), in their review on supply chain collaboration studies, concluded that there was a need to develop a model for evaluating partnership components considering multiple indicators. Recently, a few studies considered the importance of the components (e.g. Chen and Wu, 2010; Verdecho et al., 2012; Arshinder et al., 2008), nevertheless, they did not use any methods to estimate the components quantitatively in different time periods. To the best of author's knowledge, there has been no multi-criteria study that assessed the components of an ongoing partnership.

1.2 Research objectives

The overall goal of this research is to develop decision support models for partnership evaluation in the forest industry considering multiple criteria, their importance and interdependencies. In order to achieve the overall goal of the research, two specific objectives are defined as follows:

- Objective 1: Identify the types and drivers of partnerships and investigate the importance of the factors affecting the performance of forest product companies in British Columbia.

- To achieve this objective a survey of the forest companies in British Columbia, Canada is conducted and the survey's results are investigated using correlation and regression analysis.

- Objective 2: Evaluate the performance and the components of an ongoing partnership quantitatively
  - To achieve this objective multi-criteria decision support models are developed and then the models are applied to a real case study

1.3 Organization of the dissertation

Following this introduction chapter is a literature review chapter that presents previous studies on partnerships with the focus on partnership studies in forest industry. In Chapter 3, the result of a survey on partnerships in the forest industry in British Columbia, Canada is discussed. In Chapter 4, a decision support model is proposed for partnership performance evaluation over time. In Chapter 5, the second decision model is proposed to evaluate partnerships components. In both Chapters 4 and 5, the proposed models are applied to the case study and sensitivity analysis is also performed to assess the impact of variations in the value and importance of the criteria on the output of the models. The last chapter of this thesis is assigned to the final conclusions and the limitations of the study. Finally, several suggestions are given for future research direction.

Chapter 2: Literature review

2.1 Synopsis

This chapter summarizes the partnership types, drivers and the factors influencing partnership performance based on the literature, and it reviews the previous studies on partnership in the forest industry. In this chapter, first, the key factors influencing partnership performance are drawn from three major theories for inter-firm relationships: the Transaction Cost Economics (TCE), Resource-based View (RbV) and Sociological theories (Soc.). Second, the studies on partnership evaluation are reviewed. Third, previous studies in the forest products sector are discussed in two groups: 1) studies on partnership attributes, 2) studies on partnerships in logistics. In the last section, the gaps in literature are discussed.

2.2 Partnership studies

Business relationships between different companies vary in intensity and ranges from transactional (market) to integrated (mergers and acquisitions) relationships, while partnerships fall between these two extremes (Webster, 1992; Lambert et al., 1996; Daugherty, 2011). A partnership is a collaborative inter-firm relationship, characterized by asset, information and risk/reward sharing, and joint decision-making. The extensive reviews on inter-firm relationships show that the terms partnership, alliances and collaboration are used interchangeably in the literature (Arshinder et al., 2008; Daugherty, 2011). Figure 2-1 schematically illustrates the range of inter-firm relationships between two firms based on the level of commitment and trust, and information sharing (Webster, 1992; Rinehart et al., 2004). In this thesis, the focus is on partnership, which is shown in the middle of this continuous range of relationships.

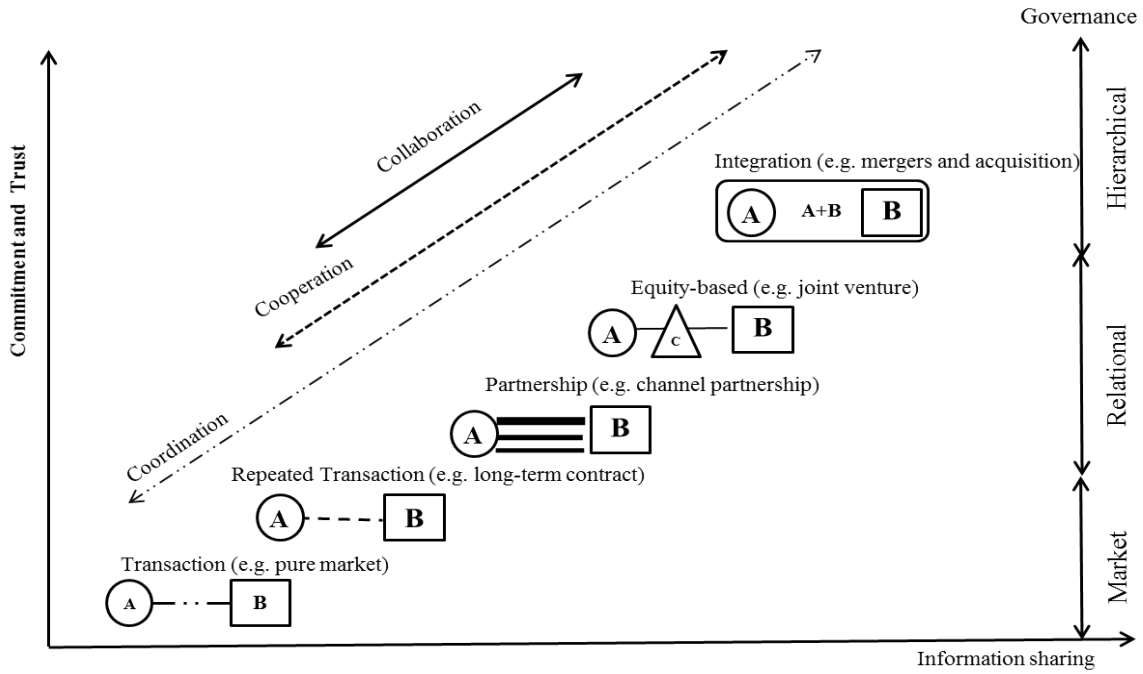


Figure 2-1. The range of inter-firm relationships (adapted from Webster 1992; Rinehart et al. 2004)

Partnership between firms can be at different echelon of a supply chain (vertical), such as partnership between manufacturers and suppliers or manufacturers and customers, or it can be between companies at the same echelon (horizontal), such as partnership between competitors (Fischer and Hartmann, 2010; Morgan and Hunt, 1994; Yoshino and Rangan, 1995). Figure 2-2 shows the different types of horizontal and vertical partnerships.

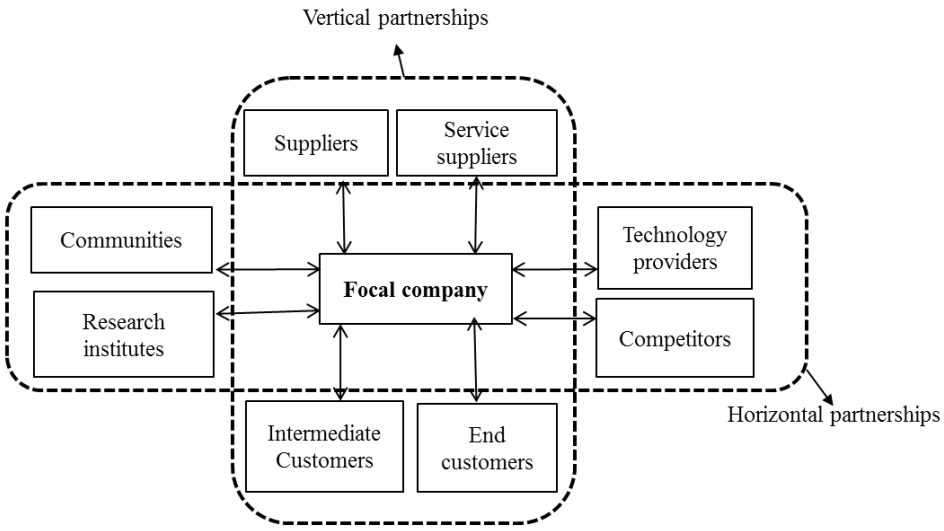


Figure 2-2. Different types of horizontal and vertical partnerships

2.2.1 Partnership theories

There is an extensive amount of literature on inter-firm relationships; however, there is no single comprehensive theory related to that (Daugherty, 2011). Studies on partnerships are characterized by diversity in theoretical frameworks, applied methods, empirical data and findings. The Transaction Cost Economics (TCE), Resource-based View (RbV) and Sociological theories (Soc.) are the main theoretical perspectives for inter-firm relationships.

The TCE theory suggests selecting an inter-firm relationship that minimizes the sum of fixed and continual transaction costs (Geyskens et al., 2006). From this theory's perspective, partnership can significantly reduce the costs of selecting and monitoring a supplier in long-term transactions with high uncertainty, and low to medium relationship-specific assets and frequency (Geyskens et al., 2006). Using the TCE theory, Heide and Stump (1995) studied 60 buyer-supplier relationships, and concluded that partnership had a positive impact on the overall performance of partners. In their study, performance was evaluated by a single Likert scale estimated by the managers.

In the RbV theory, firms are defined as a bundle of tangible and intangible resources (Eisenhardt and Schoonhoven, 1996). From this perspective, partnerships are best when a company needs resources beyond their core competency. A resource is considered as a core competency when it is valuable, rare, in-imitable, and non-substitutable (Barney, 1991). Core resources are what customers seek from a particular firm and are the basis of a firm's competitive advantage (Mudambi and Tallman, 2010). A company looking for partnership must offer something and look for complementary, or similar resources, for transferring or pooling. Considerable research attention has been given to define the specific processes where sharing resources affect partnership using the RbV theory (e.g. Barney, 1991; Peteraf, 1993; Wernerfelt, 1984). Using the RbV theory and data from 149 companies, Bharadwaj (2000) found that partnership affects profit, and cost-based performance measures positively.

Along with economic-based views of partnership formation, sociological approaches also describe inter-firm relationships. For example. institutionalization theory views partnership as a means to improve legitimacy (Bitektine, 2011; Hoffmann and Schlosser, 2001), while other studies emphasize the importance of trust and commitment, as well as, the influence of the executives' social network on partnership components and performance (BarNir and Smith, 2002).

Several studies suggest that the TCE, RbV, and Soc. theories must be considered together when making partnership decisions (Markus, 2004; Jacobides and Billinger, 2006; Mudambi and Tallman, 2010); therefore, for the development of the theoretical framework in this study, the TCE, RbV, and Soc. theories are used. Each of these theoretical perspectives contributes to the framework and provides relevant variables that influence the performance of a partnership. The relevant variables are further categorized into facilitators and components.

From the Soc. and RbV theories, when partners are relatively symmetrical and the power is balanced, the insecurity, defensiveness and fear that are often seen in an unequal partnership is less present (Lambert et al., 1996). Similarity between partners can be represented in different aspects such as the size of market share in their respective sector, reputation and technological sophistication and resources (Lambert et al., 1996). The symmetry of partners positively influences the performance of the partnership (Harrigan, 1986).

From the Soc. theory, mutual perspective about partnership, such as the level of the partnership and its time horizon are crucial for partnership. Lambert et al. (1997), in an interview of managers of 18 partnerships in the US, defines mutuality as a management team's ability to see the benefits of both sides. This ability often represents a desire to develop joint goals and take a long-term perspective.

The RbV theory assumes that partners have complementary resources and compatible business strategies (Wernerfelt, 1984). When these complementary resources are combined, they create synergies. Complementary contributions suggest that partners' business strategies should be compatible, though not necessarily identical: business strategies that do not conflict and provide a base for successful partnerships (Hoffmann and Schlosser, 2001). Compatibility between partners is positively correlated to partnership success (Saxton, 1997).

Soc. and the TCE theories demonstrate the importance of trust between partners (Hoffmann and Schlosser, 2001). Trust decreases the need for control, which in turn, results in lower transaction costs. Trust also positively influences any expansion of the partnership which, as a result, increases the benefits of the relationship (Kozak and Cohen, 1997). Due to this, it is assumed that the odds of a partnership achieving its drivers will increase if the partnership is built on trust.

Commitment is defined as a partner's belief in the importance of an ongoing partnership, and their willingness to invest resources that maintain and improve the relationship. Based on the TCE theory, any lack of commitment in the relationship increases the chance of opportunistic behavior by partners. Further, the constant measurement and enforcement of agreements that come from a lack of commitment also increase transaction costs.

Joint decision-making refers to joint planning that ranges from operational to strategic planning (Lambert et al., 1996; Simatupang and Sridharan, 2005; Arshinder et al., 2008). Based on the RbV theory, joint decision-making improves partnership performance by reducing information asymmetry (Saxton, 1997) and by increasing organizational learning and knowledge transfer between partners (Kogut and Zander, 1996). Based on the Soc. theory, joint decision-making indicates the companies' capacity to work in a collaborative environment through sharing the power (Sheth and Parvatiyar, 1992). Joint decision-making positively impacts partnership performance (Primo and Amundson, 2002).

Information sharing is defined as the formal -and informal- sharing of relevant, reliable and timely information between partners (Ramanathan, 2013). According to the TCE and RbV theories, information sharing reduces transaction costs since partners coordinate and adjust accordingly (Sodhi and Son, 2009) It also transforms knowledge resources between partners.

Risk/reward sharing refers to the processes for aligning partners' incentives by sharing costs, risks, and rewards through contracts and agreements. Based on the TCE theory, partnering companies can reduce risks in transactions with high uncertainty. Risk/reward sharing in partnership is identified as a critical factor that influence partnership performance (Lambert et al., 1996; Simatupang and Sridharan, 2005; Sodhi and Son, 2009).

Based the RbV and TCE theories, relationship-specific assets on equipment, IT and human positively affect partnership performance by increasing trust and commitment (Dyer, 1996; Handfield and Bechtel, 2002; Sodhi and Son, 2009). Partners can contribute to partnership by putting different assets into the partnership and making investments in equipment, training and organizational procedures that tailor to their partnership (Kwon and Suh, 2004; Sodhi and Son, 2009). In the literature, there are several terminologies for each factor described above. Table 2.1 summarizes the main factors investigated in this study and their relevant theories.

Table 2-1. The major factors influencing partnership performance

	Factor	Definition	Example of related studies	Theory
Facilitator	Symmetry	Similarity between partners in different aspects such as the size of market share in their respective sector, reputation and technological sophistication.	(Lambert et al., 1996; Brinkerhoff, 2002; Chen and Wu, 2010; Verdecho et al., 2012)	RbV*, Soc.**
	Mutuality	Mutual perspective about their partnership, such as the level of the partnership, its time horizon and their expectations.	(Lambert et al., 1996; Brinkerhoff, 2002; Maheshwari et al., 2006; Sodhi and Son, 2009; Chen and Wu, 2010)	Soc.
	Compatibility	Compatibility of partners such as their complimentary resources, core values and organizational structure.	(Maloni and Benton, 1997; Hoffmann and Schlosser, 2001; Brinkerhoff, 2002; Verdecho et al., 2012)	RbV
Component	Trust	The confidence and willingness of the partners to rely on the promises and actions of each other	(Moorman et al., 1993; Johnston et al., 2004; Laeequddin et al., 2010)	Soc., TCE***
	Commitment	Partners' belief in the importance of an ongoing partnership and their willingness to invest resources to maintain and improve it.	(Morgan and Hunt, 1994; Kwon and Suh, 2005; Chen et al., 2011)	TCE
	Joint-decision-making	Joint-decision-making for related activities and projects such as joint pricing, promotions, production scheduling and transportation.	(Lambert et al., 1996; Spekman et al., 1998; Brinkerhoff, 2002; Verdecho et al., 2012)	RbV, Soc.
	Information sharing	Formal/informal sharing of relevant, reliable and timely information between partners such as those about orders, inventory level and forecasting.	(Mohr and Spekman, 1994; Spekman et al., 1998; Brinkerhoff, 2002; Sodhi and Son, 2009; Kim et al., 2010)	RbV, TCE
	Risk/reward sharing	Mechanisms to align partners' incentives by sharing costs, risks, and rewards such as contracts and agreements.	(Lambert et al., 1996; Sodhi and Son, 2009; Chen and Wu, 2010)	TCE
	Relationship-specific assets	Tangible/intangible assets dedicated to a partnership that their redeployment entails considerable switching costs, such as human and IT assets.	(Lambert et al., 1996; Brinkerhoff, 2002; Beach et al., 2005; Sodhi and Son, 2009; Kim et al., 2010)	RbV, TCE

* RbV- Resource-based View (including knowledge-based view)

** Soc.- Sociological theories (including interorganizational relationship theory)

*** TCE- Transaction Cost Economics.

In this study, the null hypotheses are that these factors, partnership components and facilitators, are correlated to partnership performance. These hypotheses are tested using Pearson product-moment correlation in a survey of the forest product industry in British Columbia in the next chapter.

2.2.2 Studies on partnership evaluation

Evaluation of an ongoing partnership can be done for both performance and component. Some studies also investigate the relationship between partnership performance and components. The studies on partnership evaluation can be categorized into two groups of survey and case studies. In the first group, previous empirical studies evaluated the partnership performance of surveyed companies using either a single subjective measure (e.g. Heide and Stump, 1995; Wilson, 1995; Glaister and Buckley, 1998; Hoffmann and Schlosser, 2001; Johnston et al., 2004) or, one or more individual financial and operational performance measures (e.g. Combs and Ketchen, 1999; Bharadwaj, 2000) because partnership drivers, their performance measures, and their importance would not be the same for all the surveyed companies and it would be hard to have a single multi-dimensional measure which would be suitable for all the surveyed/investigated companies. However, from an operational point of view, it is important to evaluate the performance of a partnership in different time periods considering multiple criteria.

In the second group, the case studies and position papers, a variety of multi-criteria decision analysis (MCDA) models are developed to evaluate a partnership and each model focused on a particular stage of partnership development using the criteria important in that stage. Uncertainties, volume and frequency of transactions are often evaluated in the need assessment stage to compare the partnership approach with other alternatives such as in-house or market approaches for achieving specific drivers (Markus, 2004; Geyskens et al., 2006; Jacobides and

Billinger, 2006; Water and Peet, 2006; Mudambi and Tallman, 2010). Most decision support models have been developed for the selection stage and used multiple criteria, such as performance and compatibility, to evaluate potential partners depending on the type and the drivers of the partnership (Ho et al., 2010; Wu and Barnes, 2011; Chai et al., 2013). There are a few developed MCDA models related to the establishment stage, where different levels of partnerships are evaluated using multiple criteria. Lambert (1997) proposed an index using a simple arithmetic sum of multi-criteria to help managers choose the right level of partnership in the establishment stage. These criteria included the drivers of a partnership as well as the facilitators such as symmetry and compatibility. Simatupang and Sridharan (2005) developed a multi-dimensional index for the maintenance stage, named collaboration performance index, which is an arithmetic average of three dimensions of demand fulfilment, inventory, and responsiveness. In the proposed collaboration performance index, the measures were evaluated using a rating scale (between 0-5) by the managers in one period. The multi-dimensional indices developed by Lambert (1997) and Simatupang and Sridharan (2005) did not incorporate the importance and the interdependencies of the criteria nor any quantitative measures.

The interdependency and importance of criteria in the selection stage have been considered in several studies. Interpretive Structural Modeling (Chen and Wu, 2010) and the Decision-making Trial and Evaluation Laboratory (Chang et al., 2011) were used to consider the interdependencies of criteria. Analytic Hierarchy Process (AHP) (Bruno et al., (2012)) and Analytic Network Process (ANP) (Bayazit, 2006; Gencer and Gurpinar, 2007) were used to estimate the importance of the criteria. However, rather than using quantitative performance measures, which are not available in the selection stage, the evaluation of each partner was done by rating, or pairwise comparison, by decision-makers.

Compared to the selection stage, there are more data available in an ongoing partnership in the maintenance stage, though some measures may not be available, or accurate. It is important to consider uncertainties in the estimation of the measures, as, for example, it might not be possible to get the exact number for market share. Fuzzy logic is widely used to quantify the measures with uncertainties (e.g. Kahraman et al., 2003; Chen et al., 2006; Kannan et al., 2009; Chang et al., 2011). In multi-criteria decision support models developed for the selection stage, Fuzzy Logic (FL) was used to consider the uncertainty in pairwise comparisons of alternatives against each criterion (e.g. Kahraman et al., 2003; Perçin, 2008). The inventor of AHP criticizes FL's use in pairwise comparison because the judgments in pairwise comparisons are already linguistics and fuzzy (Saaty and Tran, 2007). FL, however, can also be used to quantify qualitative and uncertain measures by developing fuzzy sets, which was suggested by Saaty (1997).

In the next section, the previous studies on partnerships in the forest products sector are reviewed. A number of studies highlighted the opportunities for partnership in different business functions. The attributes of partnerships compared with a typical relationship have been identified in several case studies. Some studies have focused on collaboration in logistics and maximizing the benefits using mathematical modeling. However, there are a few studies on the existing and potential partnerships and the drivers of different types of partnerships in forest product supply chains. In addition, there is a gap in the literature on evaluating ongoing partnerships in the forest product supply chain using analytical tools.

2.3 Partnership studies in forestry

Several studies have identified the potential opportunities for partnership in forestry. The Biopathways project stated that in order to reach the potential global market of emerging

bioproducts, forest companies must look for new partnerships with companies outside of the forest sector (FPAC, 2011b). The report named some potential sectors for partnership, including oil and gas, chemical, auto, aerospace, and agricultural sectors (FPAC, 2011b). Janssen et al. (2008) argued that partnerships are crucial for the forest industry transformation to adjust to rapid market changes, mitigate the risk of producing new products for new markets, and secure competitive advantage in the short term. Chambost et al. (2009) categorized partnership opportunities in the forest products industry into three different categories: (1) operational partnerships, such as partnerships with feedstock suppliers, and partnerships with logistics companies that improve customer service; (2) technology partnerships, such as partnerships with technology providers that could provide the opportunity to be the first to market; and (3) financial partnerships that could help finance long-term investment projects.

In addition, researchers have studied the partnerships between forest companies, the government, and local communities. Anderson (1997) studied aboriginal businesses that had partnerships with non-aboriginal corporations. The results showed that non-aboriginal corporations increasingly intend, as part of their long-term corporate survival strategy, to build partnership with aboriginal people and governments. The author indicated that the four drivers for this intention were the increasing expectations regarding social responsibility of the companies, increasing legal and regulatory requirements and restrictions, the growing aboriginal population, and finally, the rapidly growing pool of natural and financial resources under the control of aboriginal people.

The studies on partnerships in the forest products supply chain can be divided into two groups. First, there are single and multiple cases or survey studies on existing supplier–customer (vertical) relationships that identify the partnering activities and attitudes using mostly statistical

models (e.g. Wilson and Vlosky, 1998; Cohen and Kozak, 2002; Karuranga et al., 2008; Dasmohapatra and Gonzalez, 2010). Second, some studies focused on collaboration in logistics and information sharing mechanisms in logistics using mathematical models (e.g. Audy et al., 2010; D'Amours and Rönnqvist, 2010; Frisk et al., 2010)

2.3.1 Studies focusing on partnership attributes

Several studies have investigated the partnering activities and attributes in the forest products supply chain by investigating one or more business relationships. Fontenot and Wilson (1997) looked at partner's activities to examine partnership attributes based on the literature. The authors developed a prediction matrix to test and compare the inter-firm activities of typical business relationships and partnerships between manufacturers and distributors. Later on, six group of researchers tested this matrix (Kozak and Cohen, 1997; Lawson, 1997; Lewin and Johnston, 1997; Paun, 1997; Simpson and Wren, 1997; Smith et al., 1997) in different case studies in North America. The following paragraphs briefly explain the major findings of these six studies.

The relationship between a wood distributor and its two suppliers in the United States was investigated by Simpson and Wren (1997). They used Fontenot and Wilson's prediction matrix to compare partnering activities between the wood distributor and its two suppliers. Their findings demonstrated that both relationships were similar in all partnering activities except in 4 of 35 activities, including trade discount, claim policies, relationship performance review, and special packing service. Even so, there were different levels of outcome and dependency. Their in-depth interviews showed that the degree of formal interactions did not define the efficiency of a relationship, but the informal norms and the level of trust developed in a relationship between managers defined the quality of the relationship and commitment.

Lawson (1997) performed an in-depth interview with a wood distributer in the United States about its relationship with its suppliers and customers. The investigated wood distributor had a stable income regardless of the unstable market of wood products because of the long-term partnership with both its suppliers and its customers based on mutual trust, frequent communication, information sharing, and joint activities.

In a qualitative study of a large wood products distributor in the United States that had partnership with one of its suppliers, dependency, relationship investment, switching costs, information sharing, and trust were found to be different between a partnership and a typical relationship (Smith et al. 1997). In a typical relationship, dependency, relationship investment, and switching costs were considered low by partners, and there was no information sharing (Smith et al. 1997).

Kozak and Cohen (1997) conducted a structured interview for assessing a relationship between a small Canadian distributor of forest products and one of its suppliers. They found that the investigated relationship evolved over time into a partnership with trust, commitment, regular information sharing, joint product development, and joint marketing. The result of their study showed that both partners were satisfied by their close relationship.

Wilson and Vlosky (1997) analyzed data from multiple position and case studies conducted by several researchers for manufacturer–distributor relationships in the US and Canadian wood products industry and summarized these data using meta-analysis. Their analysis showed that vertical partnerships in the wood industry center primarily on marketing and planning activities, rather than logistics and information sharing. In general, when compared with many other industries, such as automobile and electronics, the variety of products and the number of suppliers are low in the wood products industry. As a result, partnerships are more likely to occur between

suppliers and manufacturers than between other actors in the supply chain (Kozak and Cohen, 1997)

Joint sales forecasting, exchange of basic information, joint planning, and joint delivery were identified as the main indicators of collaboration in the forest products industry based on a survey of 321 forest products companies in Quebec (Karuranga et al., 2008). The findings of the survey by Karuranga et al. (2008) showed that joint replenishment systems and joint products development were specifically considered by suppliers, while exchange of performance evaluation and resource sharing of logistics assets were in the interest of customers. However, it was not investigated what type of information was shared or what activities were planned jointly. Information sharing and joint delivery were identified as the collaboration determinants in the forest industry in Quebec (Karuranga et al., 2008); this finding differs from the findings of the multi-case studies Wilson and Vlosky (1997) conducted, in which marketing and planning activities were identified as the major collaboration determinants in the forest industry. The differences in the time, geographical region, sector, and type of collaboration could be some of the reasons for the different results.

In another study, the relationship of three wood product manufacturers with their 58 customers was investigated (Lefaix-Durand et al., 2009). The authors categorized customer relationships into four groups based on their exchange value (high and low) and exchange orientation (transactional and relational) instead of the traditional transactional and relational classification. The results of their survey demonstrated that the four categories could be primarily differentiated and characterized based on the levels of the following factors: trust, cooperation, commitment, communication, time orientation, interdependency, proximity, coordination, regulation, and structure of exchange. The results showed that when compared with transactional

customers, relational customers had higher values in all 10 previously mentioned factors. Lefaix-Durand and Kozak (2010) also studied suppliers and customers' perception about the relative weights of benefits and costs in their relationship. They asked both partners about the importance of different indicators in relationship easures, such as benefits related to delivery including due time and territory coverage. The results of their study indicated that in most measures, both the suppliers and the customers had the same perceptions using the Likert scale. Using the data from the same 58 manufacture-customer relationships, Lefaix-Durand et al. (2009) used a weighted sum of benefit and cost reduction measures generated in the relationship to develop a relationship value measurement. Their survey's questions were based on seven-point continuous interval scales adapted from Eggert et al. (2006). The managers were asked as follows: "Compared to your competitors for this specific customer, how does your company perform [for customer] on a scale from 1 (much lower) to 7 (much higher) with a neutral point of 4 (neither higher nor lower than the competition)". They proposed a new relationship segmentation named "questionable", "supportive", "promising", and "strategic" based on their proposed relationship value measurement.

A survey of 78 hardwood lumber buyers (regarding their top two suppliers) in the United States showed that a close relationship with suppliers as well as product quality, overall service, and price were, respectively, the most important factors that affected the buyers' decision for selecting a supplier (Dasmohapatra and Gonzalez, 2010). However, many factors (such as production capacity) that were identified and tested in other studies (e.g. Monczka et al., 1998; Whipple and Frankel, 2000) were not included. The authors evaluated the quality of buyer–supplier relationships based on six attributes: long-term view, commitment, dependency, flexibility, switching cost, and joint activities (Caniëls and Gelderman, 2007).

2.3.2 Studies focusing on partnerships in logistics

Different studies investigated partnership in logistics in the forest product industry. Studies in this literature used the term collaboration to define the close inter-firm relationship between companies. The reviews on inter-firm relationships showed that the terms partnership, alliances and collaboration are used interchangeably in the inter-firm literature (Arshinder et al., 2008; Daugherty, 2011). Daugherty (2011) in his review on supply chain inter-firm relationship found collaboration as a terminology that has recently supplanted the terms partnering and alliances in the literature especially in studies on logistics. Collaboration in logistics, by sharing information and resources, could help different companies in the supply chain decrease the cost of logistics, improve service by reducing lead time, enter into new markets, increase the capacities, and reduce carbon emissions (Lehoux et al., 2010). Collaboration in logistics is becoming more important in different industries because of globalization and environmental issues, especially in the forest industry with high-volume products and long distances between companies in the supply chain. Transportation accounts for the second-highest cost component in forest products after harvesting (FPAC 2008), and this cost could be decreased by 5 to 15% using collaboration (Frisk et al., 2010).

Vertical partnerships in logistics between suppliers and customers in supply chain could also reduce the negative consequences of bullwhip effects, known as the magnification of demand variation moving upstream the supply chain (Moyaux et al., 2004). Two well-developed models for collaboration between buyers and customers are vendor-managed inventory (VMI) and collaborative planning forecasting and replenishment (CPFR). In VMI, the supplier manages the inventory of its buyers based on their demand information. CPFR is a collaborative management

of inventory through joint visibility and replenishment of products throughout the supply chain. Suppliers and buyers share information and plan jointly in order to satisfy customer demands.

Horizontal collaboration in logistics between different competitors or complementary companies are more complicated because of conflicting interests. Most companies are not willing to share their logistics information in this partnership, and the cost and time savings are often different between partners. Therefore, more complicated models based on game theory and economic models have been developed in different studies (Lehoux et al., 2010).

The collaboration of eight Swedish forest companies was studied in order to investigate different mechanisms to share the cost savings (Frisk et al., 2010). The findings show that collaboration could provide a 14.2% (€8m) reduction in costs and a 20% reduction in CO_2 emissions (Frisk et al., 2010). Audy and D'Amours (2008) proposed four logistics collaboration scenarios for four Canadian furniture companies. The scenarios were based on the available location of terminals and transportation systems. Then, the authors investigated the impacts of different logistics scenarios on sharing cost saving and delivery time of collaboration among the companies. The results showed that no equal and perfect benefit sharing scheme for all the companies exists. Under different scenarios, saving in costs could range from -17.3% to 29.4% and savings in delivery time could range from -72.5% to 37.0% for four companies. In another study in logistics, Lehoux et al. (2010) developed a mixed-integer linear programming model to share the collaboration profit in transportation with respect to partners' interests. The authors found a 44% potential saving in the inventory costs and an 18% saving in transportation by collaboration between a pulp and paper producer and one of its wholesalers. However, some of the previously mentioned collaboration opportunities in logistics failed to achieve their potential in the process of implementation. In the case of eight Swedish companies, only three companies

agreed to collaborate, and the savings were reduced to 1 to 2%. The collaboration between four furniture companies failed mainly because of the opportunistic behavior of one of the partners. The final collaboration between the pulp company and its wholesalers failed because the producer wanted to implement VMI, while the wholesaler did not collaborate in some activities due to concern over losing control of its operations (Audy et al., 2011). The partnership studies in forestry, along with the type and area of partnership, are summarized in Table 2-2.

Table 2-2. The studies on partnership in the forest products supply chain

Study	Region	Industry	Objective	Type	Business function	Method
Studies focusing on partnership attributes						
Wilson and Vlosky (1997)	US and Canada	Structural wood	Identify partnering activities compared with typical relationships in multiple case studies	Manufacturer–distributor	Multifunction	Multi-case and position studies–statistical test
Karuranga et al. (2008)	Canada	Forest supply chain	Identify measurement and determinants for supply chain collaboration	Buyer–supplier	Multifunction	Survey–structural equation modeling
Lefaix-Durand and Kozak (2009)	Canada	Structural wood products	Prioritize customers based on their relationship values	Manufacturer–customer	Marketing	Multicase study–descriptive statistics
Dasmohapatra and Gonzalez (2010)	US	Hardwood lumber	Examine the impact of the quality of buyer-seller relationships on choosing a supplier	Supplier–distributor	Procurement	Survey–statistical test
Studies focusing on partnership in logistics						
Audy and D'Amours (2008)	Canada	Furniture companies	Investigate the impact of benefit sharing methods and the leadership in collaborative logistics	Manufacturer–manufacturer	Logistics	Case study–mathematical programing
Lehoux et al. (2010)	Canada	Pulp and paper	Study different collaboration models	Producer and retailer	Logistics	Case study–linear programing
Frisk et al. (2010)	Sweden	Logging	Investigate different economic models to share the savings in collaborative logistics	Supplier–supplier	Logistics	Case study–mathematical modeling
Audy et al. (2010)	Sweden (case)	Logging	Determine the stable form of collaborating in terms of who should lead the collaboration and how the benefits should be shared	Supplier–supplier	Logistics	Case study–network modeling

2.4 Discussion and conclusions

Multi-criteria decision models (MCDM) were developed mainly for the selection and establishment stages rather than the maintenance stage of partnerships. MCDM models for partner selection incorporated multiple criteria such as performance and compatibility to evaluate potential partners (Ho et al., 2010; Wu and Barnes, 2011; Chai et al., 2013). Chen and Wu (2010) and Verdecho et al. (2012) included the importance and interdependencies of measures for partnership evaluation for the selection stage.

There are a few developed MCDM models related to the establishment stage or an ongoing partnership. Lambert (1997) and Simatupang and Sridharan (2005) developed MCDM models for the partnership establishment stage, but they did not incorporate the importance and the interdependencies of the measures. Furthermore, they did not evaluate partnership in different periods and did not consider different drivers of entering into partnerships.

In previous models for the selection and establishment stages, the evaluation of each partner was done by rating or pairwise comparison by decision-makers rather than using quantitative performance measures, since the values of these measures are not available at the selection stage. Based on an extensive review of the literature on MCDM models for partnership evaluation, a gap remains for multi-criteria decision support models that evaluate the performance and the components of an ongoing partnership. The review studies on inter-firm relationships revealed that the number of studies on the factors influencing partnership performance has increased; however, relatively few studies evaluated all the factors (Arshinder et al., 2008; Daugherty, 2011). Most studies investigated the determinants of partnership performance, while focusing on a specific cause–effect relationship analyzed from a particular theoretical perspective.

Although the factors influencing partnership performance are very similar, the importance of these factors could be significantly different in different contexts, such as in the industry context (De Boer et al., 2001). Previous studies in the forest products industry have focused on identifying the potential opportunities and attributes of partnerships in different business functions; however, after the review of the literature on inter-firm relationships in forestry, there are only a few studies on the types of partners, partnership drivers and the importance of the factors influencing partnership performance in the forest products supply chain.

The multiple case and survey studies on partnerships in the forest products supply chain focused on vertical (channel) partnerships mainly manufacturer-customer relationships (e.g. Wilson and Vlosky, 1998; Karuranga et al., 2008; Lefaix-Durand et al., 2009; Dasmohapatra and Gonzalez, 2010). Additionally, those studies were in the US (Wilson and Vlosky, 1997; Dasmohapatra and Gonzalez, 2010) and the two survey studies on partnerships in Canada were conducted in Quebec (Karuranga et al., 2008; Lefaix-Durand and Kozak, 2010) .

Lefaix-Durand & Kozak (2009) investigated the important factors in interfirm relationships using data from a case study, in which they looked at the relationships of three wood manufactures in Quebec with their 58 customers. They found trust, commitment, information sharing (communication), and cooperation as the major factors that differentiate relational and transactional inter-firm relationships. They investigated these factors for one specific type of vertical relationship and only from the perspective of the manufacturers' managers. In addition, they did not look at relationship-specific assets and risk/reward sharing factors. Based on the data from the same 58 manufacture-customer relationships, Lefaix-Durand et al. (2009) developed a relationship value measurement using a weighted sum of multiple benefit and cost reduction measures using seven-point continuous interval scales. They asked the managers to rate the

importance of the measures. Several studies found that estimating weights using ANP is better than manager's rating in terms of validity and reliability (Saaty, 2005).

Although, there are some studies on horizontal partnerships in logistics (e.g. Lehoux et al., 2007; Audy et al., 2007; Audy and D'Amours, 2008; Frisk et al., 2010), there is room for studies that include horizontal as well as vertical partnerships and other regions in Canada. The impact of demographic characteristics in the forest products companies on partnering practices, such as size of the company, position in the supply chain, and age of the company, are overlooked as well. The findings of this type of study could help companies within and outside the industry approach new partnerships or revise their existing ones.

In forestry, although establishing partnership has been identified as a potential way to remain competitive, a few studies focused on maintaining and improving ongoing partnerships. Therefore, there is a need to bridge the gap between these studies and develop a systematic approach for establishing a partnership based on the drivers and then evaluating the ongoing partnerships. In the next chapter, a survey of partnerships in the forest companies in British Columbia, Canada is presented.

Chapter 3: A survey on partnership components and performance in the forest product industry in British Columbia

3.1 Synopsis

The common drivers for entering into a partnership are cost reduction, marketing, product diversification and development, and customer service improvement. Previous studies revealed that achieving the drivers of a partnership depends on a number of factors, which are symmetry, compatibility, mutuality, joint decision-making, information sharing, risk/reward sharing, relationship-specific assets, and trust and commitment between partners. However, there are a few empirical studies that investigate the importance of these factors in partnership. In addition, there are a few comprehensive studies that investigate the importance of partnership drivers and the factors that influence partnership performance in the forest industry. The survey in this chapter can be divided into two sections: 1) the types of partners, the importance of different partnership drivers, and their correlations with companies' characteristics; and 2) the importance of the factors influencing partnership performance. The focus is placed on the forest industry in British Columbia (BC), which accounts for 36% of forest products export from Canada. The Canadian forest industry has the world's largest forest product trade balance (FPAC, 2015b). In this chapter, the survey of forest companies is explained including population, sample, questionnaire and responses. Then, descriptive results of survey are presented following by the results of correlation and regression analysis of the factors influencing partnership performance. At the end of this chapter, the results are discussed.

3.2 A survey of forest companies

3.2.1 Population and sample

The population of interest included all the companies in the forest products supply chain in British Columbia (BC) with more than 14 employees[1]. The forest industry is different from other previously surveyed industries, such as high-technology industries, in a number of aspects including, but not limited to, its dependency on natural resources, often its high-volume and low marginal profit products, its challenges from alternative products, and its unique opportunities for new value-added bioproducts (FPAC, 2011a). The forest products supply chain includes all the activities related to harvesting, processing of raw materials, and manufacturing of final products (Figure 3-1). Companies in the forest products industry are grouped into primary and secondary manufacturing sectors. The primary sector is comprised of companies that harvest, transport, and perform the initial processing of logs. The secondary sector includes companies that further add value to wood by drying, cutting and assembling wood products into parts or finished products.

[1] Micro-companies (companies with less 10 employees) are not included because partnerships are different in the context of micro-companies (Street and Cameron, 2007). Since 10 is not a boundary point of the grouping in the contact databases (Joint Report, 2012a), 14 is used as the closest grouping boundary.

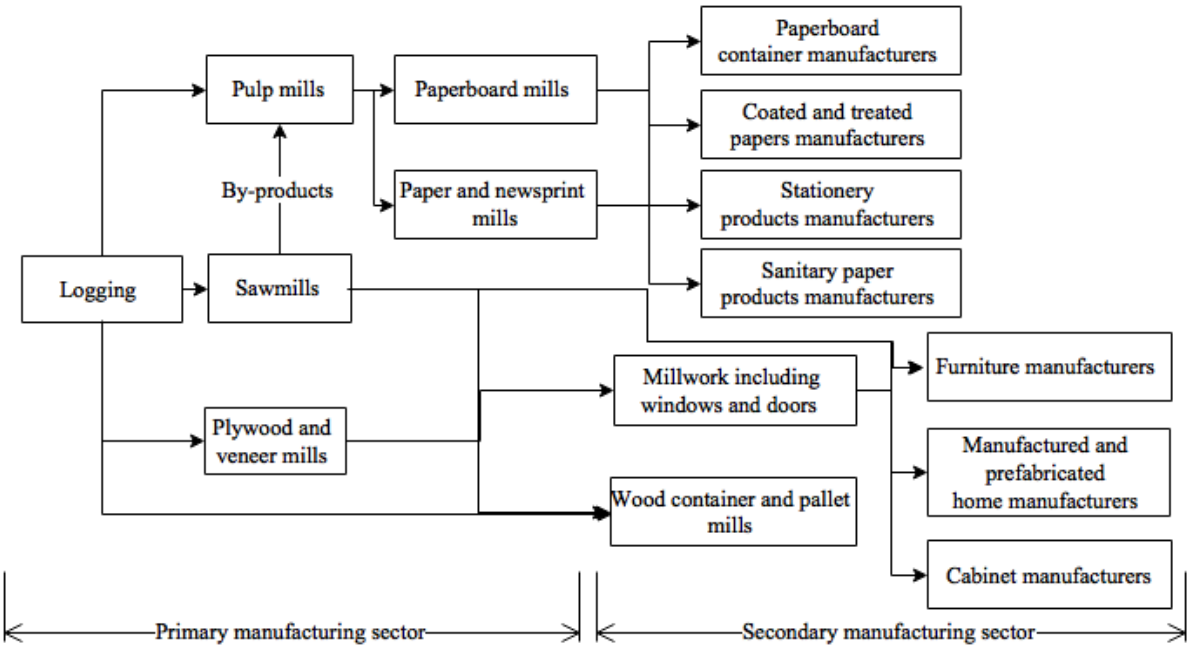


Figure 3-1. The forest product supply chain sectors based on the North American Industry Classification System (NAICS)

An electronic questionnaire was designed and emailed to companies in October 2013. The total number of companies in the forest products industry (wood and paper) was 12,372 in Canada and of which 2,174 (18% of Canada) were in BC in 2012 (Joint Report, 2012b). There were 1,023 contacts for active companies in BC from Manufacturing Directory from BC Stats, in which there were 371 contacts of companies with more than 14 employees.

In the questionnaire sent to companies, the objectives of the survey were defined as determining the existing and potential partnering practices and identifying the factors contributing to partnership performance (success) in the context of the forest product supply chain in British Columbia. A partnership was defined as a collaborative inter-firm relationship, characterized by asset, information and risk/reward sharing, and joint decision-making. The questionnaire also added that a long-term relationship with a fixed contract, and, a merger and acquisition, was not considered a partnership.

The questionnaire was sent by email in October 2013 with a cover letter to our list of 371 contacts; 85 were undeliverable (e.g. defunct business, e-mail errors), and 18 companies responded that based on the partnership definition on the cover letter they neither had any partnership nor planned to have one. Finally, 46 complete responses (17% response rate) were received. The possibility of non-response bias in our data was tested by comparing the mean of the interest variables between early and late respondents groups using t tests (Armstrong and Overton, 1977). The late wave of survey responses was considered to be representative of non-respondents. The basic rationale is that, when compared to early respondents, the late respondents are more similar to non-respondents. In November 2013, there were 27 early respondents compared to 19 late respondents. The average values for 12 questions regarding the importance of the drivers and 19 questions regarding the importance of partnership facilitators and components were tested using t test between early and late groups of respondents. The results of the t test showed that there were no significant differences ($p>0.10$) in the mean responses between early and late respondents for all those variables. The test results suggested that non-response bias might not be a problem in this study.

3.2.2 Measures

In this study, an email questionnaire was used to obtain data from forest products companies with more than 14 employees with at least one existing partnership in British Columbia, Canada. The questionnaire was divided into three main sections which included questions about 1) the company's characteristics (Table 3-1), 2) the types of their partners and the importance of their drivers (Table 3-2) for entering into the partnerships, and 3) the importance of the factors (Table 3-3) affecting the performance of their most successful partnership.

In the first section of the questionnaire, the respondents were asked to select a category that best described their company. More than two categories were used for some characteristics, however because of a limited sample in some categories, they were combined into two categories for each characteristic as shown in Table 3-1. For example, for the sector characteristic, first the industry was classified into 14 sectors based on the North American Industry Classification System (NAICS) at four-digit level. Then, the 14 sectors were further categorized into primary and secondary manufacturing sectors. Therefore, each company's characteristics became a nominal variable with two categories.

Table 3-1. The variables for companies' characteristics and their categories

Variable		First category	No*	Second category	No
C_1	Sector	Primary	24	Secondary	22
C_2	Market	Domestic-oriented (< 50% of sales)	26	Export-oriented (≥50% of sales)	17
C_3	No. of employees	Small & medium (<100 employees)	26	Large (≥100 employees)	17
C_4	Revenue	Low revenue (<$70M revenue)	33	High revenue (≥$70M revenue)	13
C_5	Establishment year	Established before 1991	30	Established after 1991	16
C_6	Management type	Managed by non-owner	27	Managed by owner	19
C_7	Associations	Non-active member	13	Active member	32

* Number of the surveyed companies in each category

In the second part of the questionnaire, the respondents were asked to select types of partners from a provided list (Table 3-2, column 1) and the importance of the drivers (Table 3-2, column 2) for entering into partnerships. The importance of each driver was asked based on a five-point interval scale of 1 to 5 (1= "Not at all", 2= "Low", 3= "Average", 4="High" and 5= "Very high"). Therefore, each type of partner is a nominal variable with two categories (0 and 1), and the importance of each driver is a nominal variable with five categories (1 to 5). The questions in this section were for the existing partnerships as well as the potential partnership for the next 5 years.

Table 3-2. The variables for the type of partner and the drivers for entering into the partnership

Variables for the type of partner		Variables for partnership driver	
P_1	Supplier	D_1	Product development
P_2	Service provider	D_2	Joint Investment
P_3	End customer	D_3	Marketing
P_4	Intermediate customer	D_4	Customer service
P_5	Community	D_5	Cost reduction
P_6	Research institute	D_6	Product diversification
P_7	Competitor	D_7	Product development
P_8	Technology provider		

In the third section of the questionnaire, the respondents were asked to indicate the importance of the factors contributing to their most successful partnership. The partnership performance was evaluated by the respondents based on the perceptual measure of the extent to which partners have achieved their drivers for entering into partnership based on a five-point interval scale of 1-100%, with 20% intervals. Thus, partnership performance is a nominal variable with five categories.

The purpose of the third section of the questionnaire was to determine the importance of the factors influencing the partnership performance in the context of the forest industry, hence all factors and their indicators are drawn from the major theories on partnership (Table 3-3). In order to capture different dimensions of each factor, multi-item indicators were used for all the factors except for trust and commitment because several review studies showed that there is no consensus about the operational indicators for trust and commitment (Goodman and Dion, 2001; Stephen James Kelly, 2004; Seppänen et al., 2007; Laeequddin et al., 2010; McEvily and Tortoriello, 2011). In multi-item indicators, each item in the questionnaire reflects one aspect of a factor in a form of a question or a statement. Multi-item indicators are superior to a single item in terms of both reliability (Haladyna, 2004) and validity (Liu, 2004). In this section, the respondents were asked about the importance of each indicator existing in 1) their partner

(facilitators), and 2) their partnership (components), both based on a scale of 1 to 5 (1= "Not at all", 2= "Low", 3= "Average", 4="High" and 5= "Very high").

Table 3-3. The variables for partnership performance and its influencing factors

Variable		Questionnaire item
Y Partnership performance		**Y_1 To what extent has your company achieved its partnership drivers**
X_i Influencing factor		
	Facilitator	**X_{1-3} To what extent are the following factors important in selecting your partner**
	X_1 Symmetry	**X_{11}** Size in terms of market share in the respective sector **X_{12}** Reputation and brand image **X_{13}** Technological sophistication
	X_2 Mutuality	**X_{21}** Having similar time horizon planned for the partnership **X_{22}** Expressing goals and sharing expectations **X_{23}** Willingness to change and integrate systems
	X_3 Compatibility	**X_{31}** Strategic plans and business objectives **X_{32}** Organizational structure
	Component	**X_{4-9} To what extent are the following factors important in your partnership**
	X_4 Joint decision-making	**X_{41}** Regular joint decision-making on partnering activities **X_{42}** Regular joint decision-making on long-term plans
	X_5 Information sharing	**X_{51}** Operational information regarding partnering activities **X_{52}:** Strategic information regarding future plans and changes
	X_6 Risk/reward sharing	**X_{61}** Defined risk/reward sharing contracts/agreements **X_{62}** Tolerance for short-term losses in favor of long-term mutual benefits
	X_7 Relationship-specific assets	**X_{71}** Personnel exchange and joint training programs **X_{72}** ICT solutions specifically for your partnership **X_{72}** Non-IT and non-human assets tailored to your partnership
	X_8 Trust	**X_{81}** Level of trust in your partnership
	X_9 Commitment	**X_{91}** Level of commitment in your partnership

3.2.3 Methods

After receiving the responses, correlation analyses were conducted using Chi-square and Fisher's Exact tests to assess the relationship between companies' characteristics (C_i) and the types of their partners (P_i) (Greenwood and Nikulin, 1996). Then, Independent Samples t-test was used to determine if there were significant differences between companies with different characteristics (C_i) and the importance of their drivers for entering into partnerships (D_i). Cronbach's alphas was used to assess the reliability of the multi-item indicators (Nunnally, 1978).

All the alpha values of the first-order factors of the multi-item indicators exceeded the 0.70 threshold level, except for the information sharing with $\alpha = 0.608$, which was still within an acceptable range (Nunnally, 1978). Moreover, the correlation between factors and partnership performance was investigated using Pearson's Product-Moment Correlation Coefficient. Finally, path analysis (Baron and Kenny, 1986) along with step-wise regression with multi-item indicators was used to identify the factors (X_i) that were the best predictors of the performance (Y) of the existing successful partnerships in the context of the forest products industry in BC.

3.3 Results

3.3.1 Descriptive results

The most common existing partnership in the surveyed companies was a partnership with suppliers (56%), while the least common partnership was a community-based partnership (11%). Figure 3-2 shows the percentages of different types of existing and potential partners for the surveyed companies with at least one partnership. Generally, there was an increasing interest in establishing partnerships with different types of partners (21%) in the next five years. For example, 30% of the surveyed companies wanted to establish partnership with communities in the next five years, while only 11% of them had community partnerships.

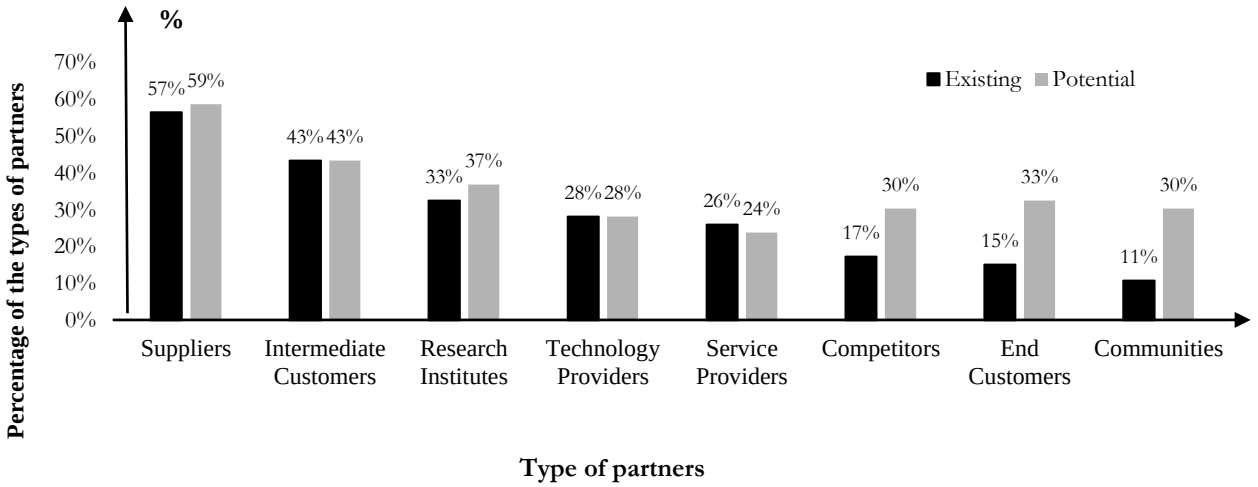


Figure 3-2. Types of existing and potential partners (in percentage) for the surveyed BC forest products companies (multiple responses possible)

Figure 3-3 shows the importance of major drivers (on average) for entering into partnership for the surveyed BC forest products companies. Customer service improvement (4.24)[2], cost reduction (4.20) and product diversification (4.11) were the most important drivers for establishing new partnerships, respectively.

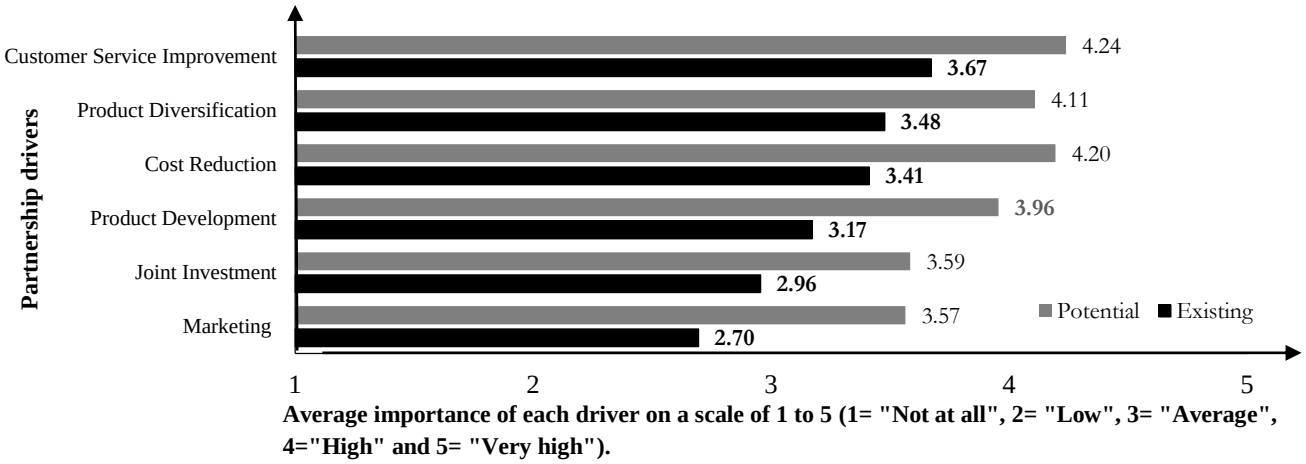


Figure 3-3. Major drivers of partnership for the surveyed BC forest products companies

The results in

[2] The values in parentheses are the importance of each driver on average in the mentioned category based on a scale of 1 to 5 Average importance of each factor on a scale of 1 to 5 (1= "Not at all", 2= "Low", 3= "Average", 4="High" and 5= "Very high")

Figure 3-4 show the importance of the factors (on average) influencing partnership performance, in which trust (3.94) and commitment (3.83) were the most important factors followed by information sharing (3.37), risk/reward sharing (3.30) and joint decision-making (3.26).

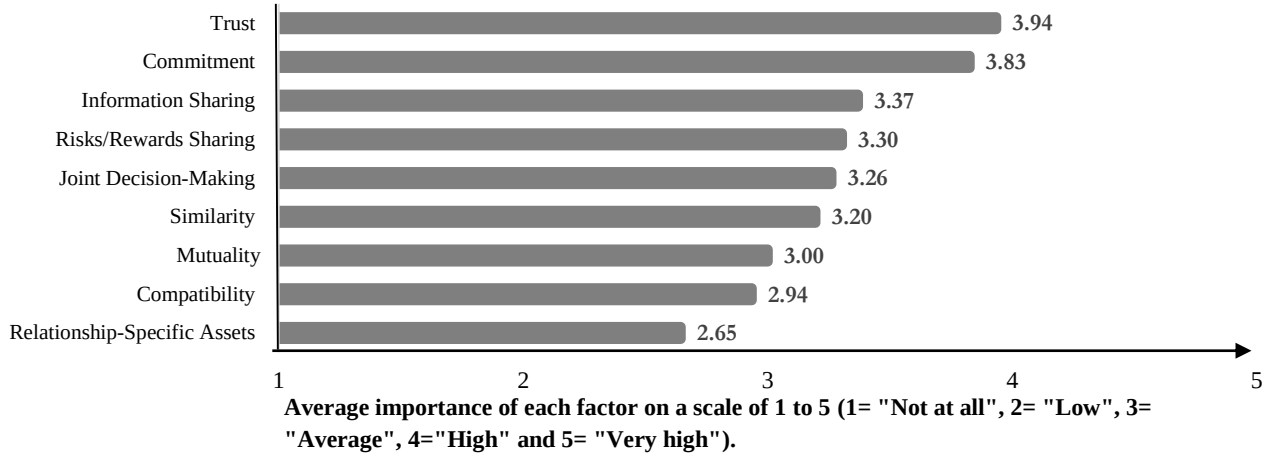


Figure 3-4. The importance of factors influencing partnership performance of the surveyed companies

3.3.2 Correlation and regression results

The Pearson Chi-square test was used to investigate the correlation between the types of existing and potential partners and company's characteristics. Findings showed that the type of partners and the importance of partnership divers were correlated with the company's position in the supply chain (primary and secondary manufacturing sectors) and its revenue.

The results showed that primary wood manufacturers had significantly[3] more partnerships with their customer (50%)[4] compared to secondary wood manufacturers (36%), while secondary wood manufacturers had more partnerships (77%) with their suppliers (mostly with sawmill

[3] Correlations are statistically significant at the 0.01 level (2-tailed).
[4] The values in parentheses are the percentages of the companies in the mentioned category with a specific partner.

companies) compared to primary wood manufacturers (46%). Large (53%) and long-established (40%) companies had more partnerships with technology providers compared to small and medium (11%) and new-established (6%) companies. Larger companies in terms of revenue (revenue >$75 million), had more partnerships with research institutes (60%) compared to the companies with lower revenue (19%). In terms of potential partnerships, export-oriented (64%), primary (46%), and high revenue (60%) companies were more willing to establish community-based partnerships in the next five years.

The comparison between the average importance of the drivers for entering into partnership between companies with different characteristics showed that customer service improvement was more important (4.14) [5] for secondary manufactures compared to that (3.25) for primary manufacturers. Joint investment was more important for the companies in primary sector (3.29) compared to that (2.59) for the companies in secondary sector. Product development was more important (3.48) for companies with higher revenue. For potential partnerships, product diversification was more important (4.50) for long-established companies compared to the new-established companies (3.90) and marketing (4.11) was a stronger driver for companies in secondary sector compared to companies in the primary sector (2.25).

With regards to the factors influencing partnership performance, except for symmetry (ρ= .020) [6] and compatibility (ρ =.133) all the other factors were correlated to the partnership performance. As can be seen in Table 3-4, trust (ρ=.771), commitment (ρ=.727) and risk/reward sharing (ρ=.608) were highly correlated factors, respectively.

[5] The values in parentheses are the importance of each driver on average in the mentioned category based on a scale of 1 to 5 (1= "Not at all", 2= "Low", 3= "Average", 4="High" and 5= "Very high")

[6] The values in parentheses are the Pearson correlation coefficient between two factors.

Table 3-4. Pearson Correlation amongst the major influencing factors and performance

Variable		Mean	S.D	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
Y	Partnership performance	3.522	.936	1									
X_1	Symmetry	3.196	.745	.020	1								
X_2	Mutuality	3.001	.596	.544**	.161	1							
X_3	Compatibility	2.935	.727	.133	.297*	.487**	1						
X_4	Joint decision-making	3.261	.848	.370*	.152	.542**	.433**	1					
X_5	Information sharing	3.370	.756	.365*	-.026	.501**	.530**	.739**	1				
X_6	Risk/reward sharing	3.304	.865	.608**	.135	.509**	.359*	.599**	.605**	1			
X_7	Relationship-specific assets	2.645	.618	.301*	.299*	.288	.392**	.463**	.533**	.552**	1		
X_8	Trust	3.935	.879	.771**	-.127	.466**	.132	.411**	.438**	.537**	.352	1	
X_9	Commitment	3.826	1.017	.727**	-.052	.427**	.225	.388**	.432**	.503**	.241	.707**	1

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Forward stepwise regression and path analysis were used in order to identify the factors that were the best predictors of the performance in the existing successful partnerships. The main assumptions underlying regression: linearity, constant variance of residuals, and normality of residuals were tested. There was no significant violation in the data set.

As seen in Table 3-4, trust and commitment were highly correlated (ρ=.707). Considering trust-commitment theory (Morgan and Hunt, 1994; Kwon and Suh, 2005), it was tested whether commitment was a mediator between partnership performance and trust. To check the mediating role of commitment between partnership performance and the dependent variable of trust, the four step approach developed by Baron and Kenny (1986) was used as follows: 1) trust was added to the regression model (β=.821, R^2=.59, p<0.001), 2) commitment was replaced with partnership performance (β=.818, R^2=.489, p <0.001), 3) commitment was added as the only predictor of partnership performance (β=.821, R^2=.585, p<0.001), and 4) commitment and trust both were added to the regression model (β=.462, R^2=.671, p<0.001). These results suggested that commitment was a mediator between trust and partnership performance. Therefore, commitment was dropped from the model. Trust is a major determinant of commitment because partnerships

characterized by trust are highly valued that partners will desire to commit themselves to such partnerships (Morgan and Hunt, 1994).

The same process was followed in order to test if trust was a mediator of all other significantly correlated variables to partnership performance based on studies on antecedents of trust in inter-firm relationships (Kwon and Suh, 2004; Chen et al., 2011). Results showed that trust was a mediator between partnership performance and three partnership factors: information sharing, joint decision-making and relationship-specific assets. However, the results suggested that trust was not a mediator for risk/reward sharing mechanism and mutuality. Therefore, trust was dropped from the model as a mediator of the other three factors. Information sharing and joint decision-making were also highly correlated (ρ =.739) and information sharing was dropped considering the model statistical coefficients and qualitative causal relationship between these two variables[7]. Based on the path analysis and step-wise regression, risk/reward sharing mechanisms (β=.395), joint decision-making (β=.394) and relationship-specific assets (β=.263) were the best predictors of the partnership performance (R^2=.495) in the context of BC forest supply chain (Table 3-5).

Table 3-5. Stepwise regression analysis for partnership performance and its influencing factors

Variable	**Unstandardized Coefficient (β)**	**Standardized Coefficient (β`)**	**Significance (ρ)**
X_4 Joint decision-making	.394	.365	.061*
X_6 Risk/reward sharing	.395	.260	.009**
X_7 Relationship-specific assets	.263	.253	.045*
b Constant	-.075		.897
R^2	.495		
$R`^2$ Adjusted R^2	.459		
F	13.714		0.000**

* Correlation is significant at the 0.10 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

[7] Information sharing is often an antecedent of joint decision making in both operational and strategic levels (Simatupang and Sridharan, 2004)

3.4 Discussion and conclusions

In this chapter, the impact of partnership facilitators and components were studied in the forest products supply chain in BC. A survey of 46 forest products companies was conducted. The questions were about the drivers for entering into partnerships, their types of partnership and the importance of partnership facilitators and components.

The results of the surveyed companies showed that there was an increasing interest (21%) in establishing new partnerships in the next five years in the BC forest products industry. Ninety-two percent of companies with partnerships wanted to keep their partnerships or establish a new partnership. This reflects the companies' satisfaction with their existing partners. This result was similar to the findings of surveys of other industries which showed interest in establishing new partnerships. For example, it was predicted in a study based on the empirical data collected through interviews of managers in six supply chains in Finnish electronics and mechanics industries that the number of partnerships in the 2010's would be 36% more than that in the 1990's (Kemppainen and Vepsäläinen, 2003).

The correlation analysis results showed significant correlation between some of company's characteristics including their revenue and their position in the supply chain (primary or secondary manufacturing sector), and the type of their partners. The companies in secondary wood manufacturing had more partnerships with their suppliers (77%) compared to companies in the primary sector (46%). More partnerships with customers in the primary sector was consistent with the previous correlation results. One of the major drivers for companies in the secondary manufacturing sector to establish partnership with their suppliers is access to a reliable and high quality supply of wood. A supply of high quality wood was identified as one of the two most important constraints to expansion in companies in the secondary sector in BC in 2006

(Stennes and Wilson, 2008). The companies in the primary sector had more partnerships with communities (46%) compared to the companies in that secondary sector (19%). Securing access to land and labour, reliable supply of timber and local reputation were reported as some of the drivers for the companies in the primary sector to establish partnership with communities (Mayers and Vermeulen, 2002).

The results for the importance of drivers showed that the most important drivers for secondary manufacturers to establish partnerships included developing new products, improving customer service, and cost reduction, while joint investment was a more important driver for primary manufacturers. This is consistent with the findings of DeLong et al., (2007), where they found cost, innovation (including new product development), and market oriented (including customer service) strategies had higher importance for the secondary manufacturers in Canada.

The result of correlation analysis between partnership performance and the investigated factors revealed that, except for symmetry and compatibility, other factors identified in previous partnership studies were significantly correlated with partnership performance; some factors were also significantly inter-correlated. These findings were generally consistent with the results of previous survey studies in other industries. The major difference was that in this study symmetry and compatibility were not strongly correlated to partnership performance. Symmetry and compatibility were considered as important factors mostly in horizontal (Saxton, 1997) and international partnerships (Kim and Park, 2002), such as partnership with competitors. In our sample, there were no such asymmetries such as national differences or partnerships with international competitors. This result confirmed that the type of influencing factors on partnership performance were very similar in different types of partnerships with different drivers.

The results of the path analysis and multi-item regression model indicated that the degree of joint decision-making, relationship-specific assets and risk/reward sharing mechanisms were the best predictors of the performance in the existing successful partnerships of the surveyed companies. The results in this section were notably different from results found in other non-forest products industry studies. These differences could be discussed based on the context and theory/methodology. In terms of context, differences in the results might be due to the differences in industry, time, geographical region, sector, and type of inter-firm relationships. For example, in a study of 74 supplier-retailer partnerships in South Korea, Sodhi and Son (2009) found trust, information sharing and joint decision-making as the most important factors influencing partnership performance. In another study by Ellram (1995), information sharing, mutuality (in management support and goals) were identified as the most important factors. Additionally, the reason that in this study mutuality was not among the main predictors of partnership performance could be because respondent companies had mutual perspective when both partners looked at partnerships as a strategy to remain competitive. In the context of inter-firm relationships between suppliers and customers, using a survey of 321 forest products companies in Quebec, Karuranga et al. (2008) found information sharing and joint decision-making (joint planning) factors as the main indicators of partnership (collaboration). Lefaix-Durand & Kozak (2009) conducted another study in the wood product sector, based on the relationships of three manufactures in Quebec with their 58 customers in the US and Canada. They found trust, commitment, information sharing (communication), and cooperation were the major factors that differentiate relational and transactional inter-firm relationships. Lefaix-Durand & Kozak (2009) looked at only manufactures-customers relationships and from the perspectives of the manufactures (six managers).

Chapter 4: A decision support model for evaluating partnership performance

4.1 Synopsis

In Chapter 3, partnership performance and the factors influencing it were evaluated subjectively by asking respondents' perceptions using Likert scales. However, from an operational perspective, it is important to evaluate partnership objectively using quantitative measures and indicators. The lack of comprehensive partnership evaluation has been identified as one of the main reasons for partnership failure (Hoffmann and Schlosser, 2001; Holmberg and Cummings, 2009). In this chapter, first partnership's drivers and measures are reviewed from previous studies. Then, the decision-makers are asked to weigh the drivers and measures. Next, Interpretive Structural Modeling (ISM), Analytic Network Process (ANP) and Fuzzy Logic (FL) are used to evaluate interdependency, importance of, and uncertainty in these measures. Finally, a multi-criteria decision support model is used to evaluate the performance of an ongoing partnership in different periods based on the measures associated with the drivers for entering into the partnership. Model outputs are: the importance of each performance measure and, a single number for overall partnership performance in each period, named as Partnership Performance Index (PPI), which are discussed in the Discussion and conclusion section of this chapter.

4.2 A decision support model for evaluating partnership performance

In order to develop a model for partnership evaluation, evaluation criteria must be defined. There are a variety of criteria for evaluating partnerships. Criteria such as financial (Luo and Chen, 1995) and operational efficiency (Kim and Park, 2002) have been used frequently. Simatupang and Sridharan (2005) used three operational measures including fulfilment rate,

inventory, and responsiveness to estimate partnership performance for supplier-buyer partnership. Sodhi and Son (2009) used different measures to evaluate the strategic and operational performance. No consensus has been reached on measures for partnership evaluation (Sodhi and Son, 2009; Chen and Wu, 2010). Each partner should define and evaluate their drivers and measures individually (Lambert et al., 1996). The current literature indicates that clear and specific drives and consistency in measuring performance are the key to successful partnership (Gunasekaran and Kobu, 2007). In this study, supply chain performance measures are drawn from two comprehensive frameworks (Kaplan and Norton, 1996; Gordon Stewart, 1997) and two review studies (Gunasekaran and Kobu, 2007; Shepherd and Günter, 2011). According to the literature, these measures are categorized based on partnership drivers (Table 4-1).

Table 4-1. Common partnership drivers and performance measures

Driver	Number	Measure	Kaplan and Norton, 1996	Gordon Stewart, 1997	Gunasekaran and Kobu, 2007	Shepherd and Günter, 2011
Customer service	1	Compliance to regulation			×	×
	2	Conformance to specifications			×	×
	3	Procurement lead time	×	×	×	×
	4	Manufacturing lead time		×		×
	5	Scheduling accuracy	×	×	×	×
	6	Forecasting accuracy	×	×	×	×
	7	Delivery reliability			×	×
	8	Delivery lead time		×		×
	9	Perceived quality			×	×
Product diversification	10	Product variety	×		×	×
	11	Service variety	×		×	×
	12	Production flexibility			×	×
Cost reduction	13	Transportation cost		×	×	×
	14	Inventory cost	×	×	×	×
	15	Overhead cost			×	×
	16	Procurement cost	×	×	×	×
	17	Obsolescence cost	×		×	×
	18	Stock-out cost	×		×	×
	19	Warranty cost	×	×	×	×
	20	Product development cost	×			×
	21	Capacity utilization			×	×

Driver	Number	Measure	Kaplan and Norton, 1996	Gordon Stewart, 1997	Gunasekaran and Kobu, 2007	Shepherd and Günter, 2011
	22	Labor efficiency	×		×	×
	23	Marketing cost		×		
Product development	24	New product development	×			×
	25	Product development time	×		×	×
Joint projects/ investment	26	Joint projects (number)			×	×
	27	Joint projects (value)			×	
	28	Cash flow time	×		×	×
Marketing	29	Market share		×		
	30	Sales				×
	31	Sales to new customers		×		×
	32	Sales from a new product	×			×
	33	Distribution availability				×
	34	Brand image/reputation				
	35	Value added		×		×
	36	Perceived value of a product	×		×	×

There are a few multi-criteria decision support models in the literature for quantitatively evaluating an ongoing partnership. For example, Simatupang and Sridharan (2005) developed a simple multi-criteria model for partnership evaluation, named Collaboration Performance Index, which was an arithmetic average for three dimensions of fulfilment, inventory, and responsiveness with multiple measures for each dimension. However, they did not consider the importance and the interdependencies of the measures and they used managers' ratings rather than quantitative measures. Chen and Wu (2010) and Verdecho et al. (2012) included the importance and interdependencies of measures for partnership evaluation for the selection stage. However, they did not evaluate partnership in different periods and did not consider different drivers of entering into partnerships. The proposed multi-criteria model is developed for evaluation of an ongoing partnership using multiple measures for each driver in which the importance and the interdependences of the measures are incorporated to the model.

The proposed multi-criteria model is schematically presented in Figure 4-1. The highest level of the model presents the objective which is to evaluate the partnership performance. Examples of drivers and measures in Figure 4-1 drawn from the literature. The second and third levels include the criteria (drivers) and sub-criteria (measures) of the partnership, respectively. The lowest level consists of the alternatives, which are the partnership in different periods. In the next section, each step of the modeling approach is explained in detail.

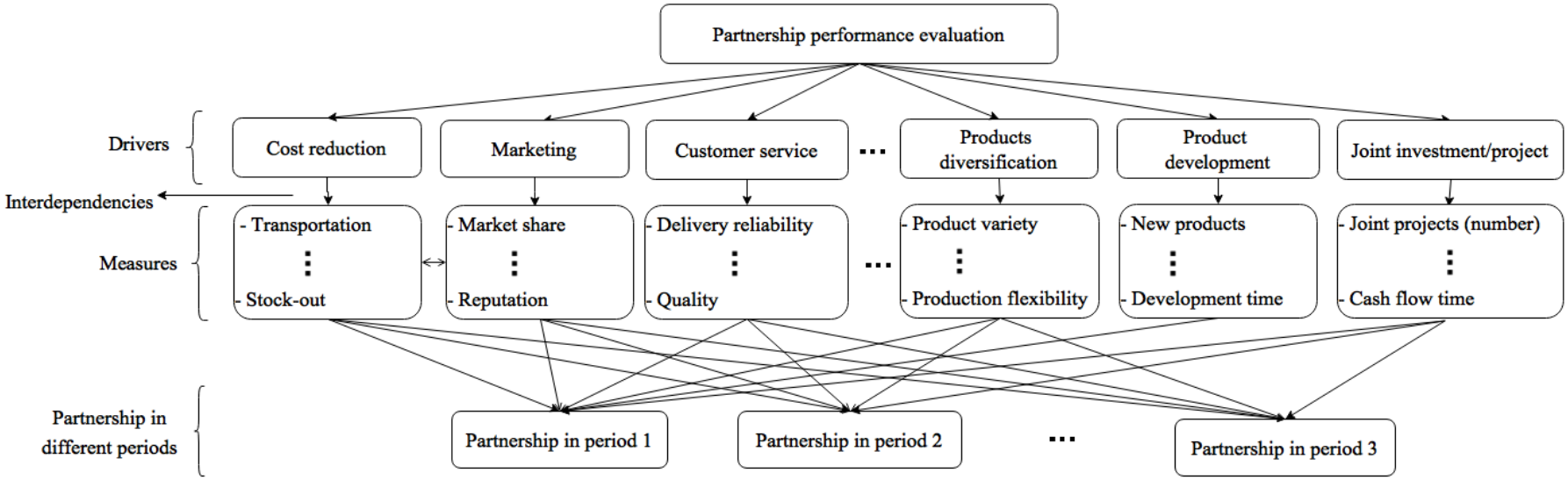


Figure 4-1. The proposed multi-criteria model for evaluating the performance of an ongoing partnership in different periods.

The modeling approach proposed in this study consists of five steps: 1) define the drivers, and performance measures, 2) evaluate the interdependencies, 3) estimate the importance of the drivers and measures, 4) quantify and normalize the performance measures for partnership in different periods (alternatives), and 5) calculate the overall Partnership Performance Index (PPI). Figure 4-2 shows the flowchart of the proposed modeling approach for calculating the Overall Partnership Performance Index (PPI).

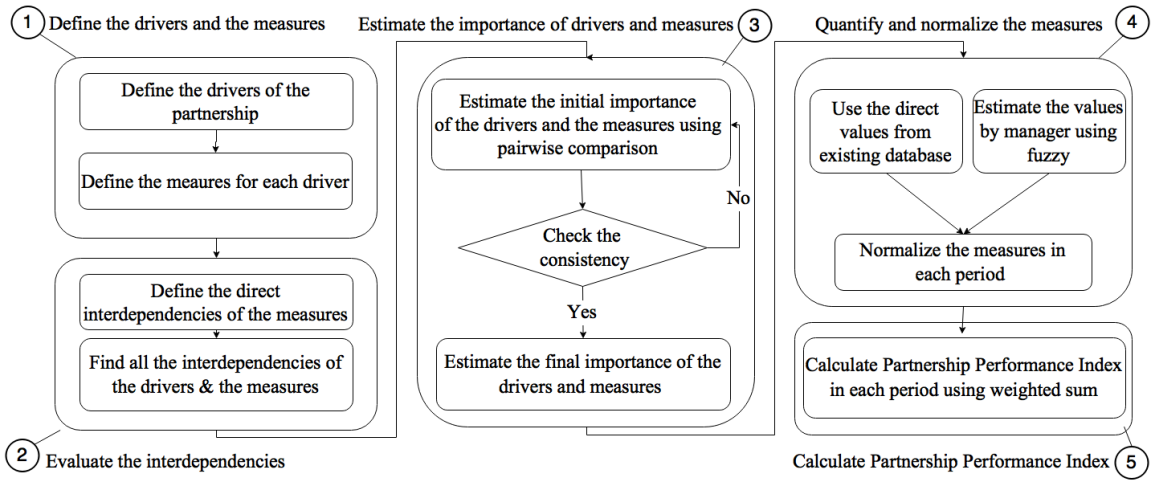


Figure 4-2. The steps of the proposed modeling approach for calculating the final Importance of the Measures (IM) and the overall Partnership Performance Index (PPI)

4.2.1 Define the drivers and the measures

Decision-makers can select their drivers and performance measures from the identified drivers and measures (Table 4-1) or they can add their specific ones. The predefined list is simply meant to identify examples that may be relevant.

4.2.2 Evaluate the interdependencies of drivers and measures

There are often interdependencies among the drivers and performance measures (Chen and Wu, 2010). Therefore, it is important to first investigate these possible interdependencies and then use an appropriate MCDA method for evaluation. There are different methods to determine the interdependencies among variables in complex problems that have limited historical data, which is often the case in business partnerships. These methods include, but are not limited to, Interpretive Structural Modeling (ISM) and the Decision-making Trial and Evaluation Laboratory (DEMATEL) (Tzeng and Huang, 2011). Choosing a method for determining interdependencies depends on the availability of data, the complexity of the problem and the number of variables in the model (Tzeng and Huang, 2011).

In the proposed model, Interpretive Structural Modeling (ISM) is used to determine the interdependencies among the measures. ISM is an algebraic technique for analyzing indirect interdependencies among variables (Thakkar et al., 2006). The main reason for choosing ISM in this study is because only the interdependencies, not their magnitude, are required at this stage. Magnitude of interdependencies are estimated in the process of applying ANP in the next step. In ISM, decision-makers determine the direct interdependencies among the criteria. Then, ISM is used to check for consistency and to identify all other interdependencies. The procedure of ISM is as follows (Warfield, 1982):

Step 1: Constructing the Relation Matrix *(D)* which is a binary $n \times n$ matrix for a system with n variables, in which each entry d_{ij} in $D = [d_{ij}]$ is assigned as follows:

- $d_{ij} = 1$ if variable n_j is under the direct influence of variable n_i
- $d_{ij} = 0$ otherwise

Step 2: Calculating Reachability Matrix (M^*) by raising the sum of Relation Matrix *(D)* with Boolean Unity Matrix *(I)*[1], called *M*, to successive powers until there is no new entries. M* represents all interdependencies between system variables. In M^*, entry $r_{ij}=1$ indicates that variable n_j is under the direct or indirect influence of variable n_i. Equation (4.1) shows the calculation process of M^* where k denotes the powers and the operators are Boolean:

$$M^* = M^k = M^{k+1}, \qquad M = (D + I) \;\; and \;\; k > 1 \tag{4.1}$$

4.2.3 Estimate the importance of drivers and measures

The performance measures in a partnership depends on underlying drivers. The drivers may have different importance which has been considered in studies related to the selection stage (De Boer et al., 2001) but have been overlooked in studies related to the maintenance stage. In this step, ANP is used to estimate the importance of all the drivers and measures, considering the interdependencies among the

[1]Boolean Unity Matrix is the n × n square matrix with ones on the main diagonal and zeros elsewhere

measures. There are three main reasons for using ANP for partnership evaluation relative to other MCDM methods. First, ANP can model complex problems with a network structure and interdependencies among variables (Saaty, 1996). Second, ANP is adequate for solving problems with both qualitative and quantitative factors (Forman and Selly, 2003; Yurdakul, 2003; Khan and Faisal, 2008). Third, ANP has been used in group-decision problems that are in accordance with the decision-making environment for partnerships (Saaty, 1996; Verdecho et al., 2012). Different methods have been developed for aggregation of individual responses and for feeding them into the ANP model (Ramanathan and Ganesh, 1994; Van Den Honert and Lootsma, 1997; Bolloju, 2001; Escobar and Moreno-jiménez, 2007).

ANP starts with a series of pairwise comparisons of variables. The pairwise comparison of each group of the variables (cluster) against a criterion is represented in a pairwise comparison matrix (PCM), called A. In a PCM, each comparison is a question for decision-makers and the answer is an entry *(a_{ij})* in A, a_{ij} represents the relative importance of variable n_i over n_j evaluated based on the criterion c_k. In the proposed model, a_{ij} ranges from 1, 3, 5, 7 to 9 as the relative importance of n_i increases. On the contrary, if n_i is less important than n_j, a_{ij} ranges from 1, 1/3, 1/5, 1/7 to 1/9 as the importance of n_i declines. The initial importance of the variables in A is column vector ω, $\omega = [\omega_1, \omega_2, \dots, \omega_n]^T$, which is the corresponding eigenvector of the largest eigenvalue, λ_{max} , from the following equation (4.2) (Saaty, 2008).

$$A = [a_{ij}]_{n\times n} \quad A\omega = \lambda_{max}\,\omega \tag{4.2}$$

In practice, the pairwise comparisons performed by the decision-makers can be inconsistent, which makes the associated matrix inconsistent. Consistency of each matrix (A) has to be checked by examining the Consistency Ratio *(CR)*, which is given by equation (4.3) (Saaty, 2008).

$$CR = \frac{CI}{RI} \quad where \quad CI = \frac{(\lambda_{max} - m)}{(m-1)} \tag{4.3}$$

Where *m* is the number of pairwise comparisons, Consistency Index (*CI*) is the deviation of eigenvalue and Random Index (*RI*) is the average *CI* over a large number of reciprocal matrices with random entries.

The consistency of pairwise comparisons are accepted if $CR < 0.1$; otherwise, they should be reevaluated (Saaty, 1980).

Then, all the initial importance resulted from PCMs are fed into a matrix which includes all the variables in the decision model, called Super-matrix (S). If a model comprises of N clusters, $D_1; D_2; \ldots D_N$, and the k_{th} cluster D_k consists of n_k variables, $n_{k,1}, n_{k,2}, \ldots n_{k,nk}$, then the interdependencies between the clusters will be given in S, as presented in equation (4.4). Where A_{ij} is a $n_i \times n_j$ sub-matrix representing the initial importance of the variables in D_i on the criteria in D_j. If there is no direct interdependency between two clusters, the corresponding sub-matrix is zero.

$$S = \left[A_{ij}\right]_{N\times N} \; where \; A_{ij} = \left|A_{ik}^{jl}\right|_{n_i \times n_j} \tag{4.4}$$

The final importance of all measures are given by the Limiting-matrix (L) of Super-matrix (S) as presented in equation (4.5):

$$L = \lim_{n\to\infty} S^n \tag{4.5}$$

One of the practical issues with implementing of ANP is the large number of pairwise comparisons required from the decision-makers. Each PCM is a reciprocal matrix with the sum of its trace values equal to the number of the variables (n). The number of comparisons (m) required for each PCM in the model is given by equation (4.6):

$$m = \frac{n(n-1)}{2} \tag{4.6}$$

There are several mathematical methods to reduce the number of pairwise comparisons such as balanced incomplete block design (Weiss and Rao, 1987), incomplete pairwise comparison method (Harker 1987) and attribute subsets (Shen et al. 1992). In this study, Incomplete Pairwise Comparison (IPC) is used (Harker 1987). IPC is simple and validated by other studies (Carmone Jr et al., 1997; Setiawan, 2002). The IPC method involves the following three simple rules for obtaining the incomplete matrix approximation of the full matrix: 1) keep all comparison values given by the decision-makers, 2)

enter a "0" for every missing entry of the PCM, and 3) replace the trace with a value equal to the number of zeros in that row plus one. The right principal eigenvector of this new matrix is the decision-makers' approximate importance vector (Harker 1987). Using this method, the number of pairwise comparisons required to derive the relative importance vector (ω) is (n - 1).

Reducing the pairwise comparisons does not necessarily improve the accuracy or robustness of the ANP decision-making; however, it is very desirable especially when more than one decision-maker is involved in the decision-making process. A high number of pairwise comparisons makes the model less desirable for practitioners and it increases the potential of making mistakes and being inconsistent. There are several studies on the impact of reducing the number of pairwise comparison on the accuracy of the results. Carmone et al. (1997) conducted a Monte Carlo simulation to determine the effectiveness of IPC using 11 performance measures. They concluded that up to 90% of comparisons could be deleted from the PCM using the IPC method and it still could yield a priority vector that approximates the true priority vector with sufficient accuracy (Carmone et al., 1997). A separate simulation study (Setiawan 2002) concluded that for a 10 x 10 matrix, nine comparisons would yield an accuracy of 97.6-98.9%. These results show that the benefits of reducing the number of pairwise comparisons outweighs the insignificant changes in accuracy.

4.2.4 Quantify and normalize the performance measures

In this step, partnership performance in different periods are evaluated against each measure. In the proposed model, direct quantitative values are used to evaluate the partnership performance in each period rather than pairwise comparison. There are three advantages to using quantitative values. First, they are generally based on facts and less prone to bias. Second, they significantly reduce the number of questions asked from the decision-makers in the model. Last but not least, it is possible to evaluate partnerships in different time periods without requiring the comparison with the partnership performance in previous time

periods. This also makes the model less susceptible to rank reversal problems (Bruno et al., 2012). Rank reversal is a phenomenon associated with the resulting of a different rank for previous alternatives when new alternatives are added to an existing multi-criteria decision-making model (Belton and Gear, 1983). Rank reversal happens when decision-makers need to repeat the previous pairwise comparison as well as consider new alternatives (Wang and Elhag, 2006). There is no need to do the pairwise comparisons by the decision-makers when using quantitative values.

For measures with uncertain, or limited, data, the decision-makers could be asked to estimate the measures using predefined fuzzy sets in order to capture the uncertainties. The fuzzy sets' major contribution is their ability to quantitatively represent uncertain estimations. Trapezoidal functions are applied to create predefined fuzzy sets because of their simplicity and the nature of the estimated measures. A trapezoidal function is defined by a lower limit *a*, an upper limit *d*, a lower support limit *b*, and an upper support limit *c*, where $a < b < c < d$ (George and Yuan, 2001).

The problem with using quantitative measures is that the values may be in different units as opposed to the values resulted from pairwise comparisons (Saaty, 2005). Therefore, the measures should be normalized so that the intervals are similar and arithmetic calculations can be applied. In this method, each measure is normalized between [0-1] by dividing the value of the measure in each period by the sum of all the values in different periods as presented in equation (4.7), where x'_{ti} is the normalized value of measure *i* in time period of *t*, x_{ti} is the actual value of measure *i* in time period *t*, and *k* is the number of periods for partnership evaluation.

$$x'_{ti} = \frac{x_{ti}}{\sum_{t=1}^{k} x_{ti}} \tag{4.7}$$

To normalize the fuzzy measures, first they need to be quantified using a defuzzification method. The centroid method is used for defuzzification of the fuzzy measures (Van Leekwijck and Kerre, 1999). The centroid method is applied for defuzzification because of its accuracy, the type of our measures, the

membership type and the support of previous research (Chou and Chang, 2008). The centroid defuzzification technique can be expressed as equation (4.8) (Van Leekwijck and Kerre, 1999):

$$x_{ti}^{*} = \frac{\int \mu_i(x)\, x_{ti}\, dx}{\int \mu_i\,(x)\, dx} \tag{4.8}$$

Where x_{ti} is the defuzzified output, $\mu_i(x)$ is the aggregated membership function and x_{ti} is a measure.

4.2.5 Calculate Partnership Performance Index (PPI)

In the final step, the Partnership Performance Index (PPI), presented in equation (4.9), is calculated using the weighted sum of the quantified and normalized values of measures in period (*t*) multiplied by the final importance of the measures:

$$PPI(t) = \sum_{i=1}^{n} w_i * x'_{ti} \tag{4.9}$$

Where w_i is the final importance of measure (*i*), *n* is the total number of measures, and $x'_{ti}$is the normalized value of the measure *i* in time period *t*. This index captures all the measures related to partnership drivers, their importance, interdependencies and uncertainties.

4.3 Applying the model to the case study

The case study in this research is related to a partnership between a forest company and a sawmill in Maple Ridge, British Columbia, Canada. The core competency of the forest company is in its forest management operations. The forest company faced significant fluctuations in log demand and profit margins. The company had no experience processing the logs and did not have the market to sell them before 2004. On the other hand, the sawmill is specialized in the manufacturing and marketing of wood products, but was facing challenges due to an uncertain supply of logs and high overhead costs.

The forest company and the sawmill established a partnership in 2004. The sawmill moved its facilities to the forest area that is managed by the forest company. The forest company provided access to reliable

log resources, land, regional goodwill, and a positive corporate image. The sawmill company brought its years of experience in the sawmill industry, equipment, and established network of customers.

After more than 10 years, both companies are satisfied with the results of the partnership. The forest company has been receiving between 10-50% more value from the same logs which are directly sold in log markets. The sawmill's production capacity has increased by 50% since the partnership began and its overhead costs have been decreased significantly. Currently, the sawmill has competitive advantage over other sawmills due to its reliable log supply where competitors need to pay a premium to buy and transform logs from the market with an associated uncertainty in price and supply.

The proposed decision support model is applied to the case study. The general managers of the two companies are the decision-makers in the partnership.

4.3.1 The drivers and the measures

The drivers of the partnership and their measures and importance are different for each partner; therefore, two different models are developed to evaluate the partnership performance. From the list of identified drivers and measures (Table 4-1), each manager was asked to select the relevant ones for their partnership and the most convenient method to estimate the measures. If their drivers and measures were not in the provided table, they were asked to define their specific drivers and their relevant measures. Table 4-2 summarizes the drivers, the measures, and their quantifying method for the forest and the sawmill companies. In this study, joint projects were defined as one of the drivers by the managers. The driver for these joint projects could not be explicitly represented under other drivers; therefore, it was defined as a separate driver for the case study. In this case study, the joint projects included several extension projects such as construction of recreational facilities in the forest area by the sawmill company.

Table 4-2. The measures and quantification method for the forest company and the sawmill

	Driver	Measure	Unit	Quantification
The forest company	Marketing (D_{A1})	Reputation (V_{A1})	Customer loyalty (%)	Data
		Sales (V_{A2})	Value of sales ($)	Data
		Sales to new customers (V_{A3})	Share of the sales to new customer (%)	Data
		Market share (V_{A4})	Share of targeted market (%)	Estimated
	Product diversification (D_{A2})	Product variety (V_{A5})	Yearly product categories (#)	Data
		Production flexibility (V_{A6})	Monthly production range (m^3/week)	Data
	Joint projects (D_{A3})	Joint projects (number) (V_{A7})	Number of joint projects (#)	Data
		Joint projects (value) (V_{A8})	Value of joint projects ($)	Data
		Cash flow time (V_{A9})	Inventory turn-over (Day)	Data
The sawmill	Cost reduction (D_{B1})	Inventory cost (V_{B1})	Opportunity cost of the logs in the inventory ($)	Data
		Overhead cost (V_{B2})	Fixed costs include utilities and insurance ($)	Estimated
		Stock-out cost (V_{B3})	Cost of the purchased logs from the market ($)	Data
		Labor productivity (V_{B4})	Production value per direct labor ($/labor)	Data
	Customer service (D_{B2})	Procurement lead time (V_{B5})	Time between order and delivery (Day)	Estimated
		Delivery lead time (V_{B6})	Time between manufacturing and delivery (Day)	Estimated
	Joint projects (D_{B3})	Joint projects (number) (V_{B7})	Number of joint projects (#)	Data
		Joint projects (value) (V_{B8})	Value of joint projects ($)	Data
		Cash flow time (V_{B9})	Average cash-flow time from customers (Day)	Estimated

4.3.2 The interdependency of the measures

The measures selected by the managers of both companies were listed and they were individually asked "Does the measure V_i directly have a strong effect on the measure V_j?" If the answer was "Yes" then the related value in the matrix would be 1, otherwise it would be 0. Table 4-3 and Table 4-4 show the Relation Matrix for both the forest company and the sawmill.

Table 4-3. The Relation Matrix (D) for the measures of the forest company

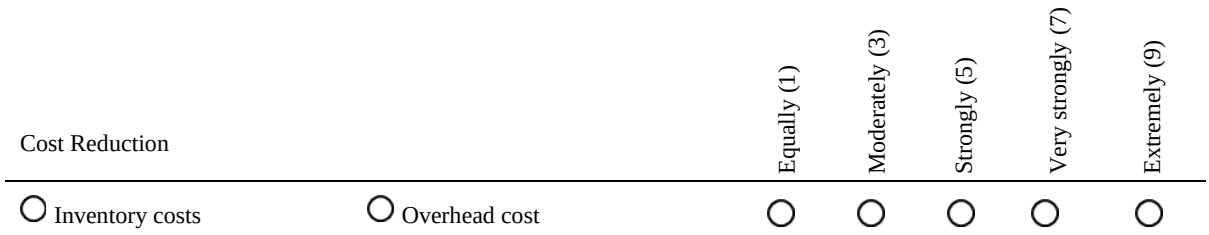
Measures	**V_{A1}**	**V_{A2}**	**V_{A3}**	**V_{A4}**	**V_{A5}**	**V_{A6}**	**V_{A7}**	**V_{A8}**	**V_{A9}**
Reputation (V_{A1})	0	1	1	0	0	0	0	0	0
Sales (V_{A2})	1	0	0	1	0	0	0	0	1
Sales to new customers (V_{A3})	0	0	0	1	0	0	0	0	0
Market share (V_{A4})	1	0	0	0	0	0	0	0	0
Product variety (V_{A5})	0	1	1	1	0	0	0	0	0
Production flexibility (V_{A6})	0	1	1	1	0	0	0	0	0
Joint projects (number) (V_{A7})	0	0	0	0	0	0	0	0	0
Joint projects (value) (V_{A8})	0	0	0	0	0	0	0	0	0
Cash flow time (V_{A9})	0	0	0	0	0	0	0	0	0

Table 4-4. The Relation Matrix (D) for the measures of the sawmill

Measures	**V_{B1}**	**V_{B2}**	**V_{B3}**	**V_{B4}**	**V_{B5}**	**V_{B6}**	**V_{B7}**	**V_{B8}**	**V_{B9}**
Inventory cost (V_{B1})	0	0	1	0	0	0	0	0	0
Overhead cost (V_{B2})	0	0	0	0	0	0	0	0	0
Stock-out cost (V_{B3})	1	0	0	0	0	0	0	0	0
Labor productivity (V_{B4})	0	0	0	0	0	0	0	0	0
Procurement lead time (V_{B5})	1	0	1	0	0	0	0	0	0
Delivery lead time (V_{B6})	1	0	1	0	0	0	0	0	1
Joint projects (number) (V_{B7})	0	0	0	0	0	0	0	0	0
Joint projects (value) (V_{B8})	0	0	0	0	0	0	0	0	0
Cash flow time (V_{B9})	0	0	0	0	0	0	0	0	0

4.3.3 The importance of the partnership drivers and the measures

The initial importance of the drivers and the measures are estimated using pairwise comparison matrices (PCM). Each comparison in PCM is in the form of a question from the managers. For example, the following question is asked to compare measure V_{B1} and V_{B2} under D_{B1} driver, "With regards to the "Cost Reduction" driver, which measure (inventory cost or overhead cost) is more important and by how much?"



Then, the results of the pairwise comparisons are inserted into the associated PCM to check for consistency and to calculate the initial importance. For example, the associated PCM for comparing the measures for cost reduction is presented in Table 4-5. The empty cells (comparisons) are estimated using the Incomplete Pairwise Comparison (IPC) method.

Table 4-5. Pairwise comparisons and relative importance of criteria under a criterion (D_{B1})

D_{B1}	V_{B1}	V_{B2}	V_{B3}	V_{B4}
V_{B1}	1	1/7	-	3
V_{B2}	7	1	7	9
V_{B3}	-	1/7 -	1	-
V_{B4}	1/3	1/9	-	1

Finally, the initial importance from PCMs are fed into the Super-matrix (S) in ANP to estimate the final importance of the measures considering their interdependencies.

4.3.4 Quantifying and normalizing the measures

For the measures with quantitative data, values from corresponding datasheets were used, while for the measures estimated by managers, different fuzzy sets were defined for the possible intervals of each estimated measure. Then, each manager was asked to estimate the percentage of the time that the measures occurred at different intervals in each period. For example, for procurement lead time, the manager of the sawmill was asked about the total range and the intervals for which the manager was *very satisfied*, *satisfied*, and *not satisfied* with the procurement times. There is no exact number as a boundary between these intervals. Sometimes 20 days can be considered *very satisfied* for procurement time but sometimes 20 days can be only satisfied based on for example the order and the client. Next, the manager was asked

to estimate the percentages of procurements that happened in each category for each year. For example, in 2012, 70% of the procurements' time was considered *satisfied*, 20% *not satisfied* and 10% *very satisfied*. Figure 4-3 show the variables describing the state of the measures and the corresponding trapezoidal fuzzy sets.

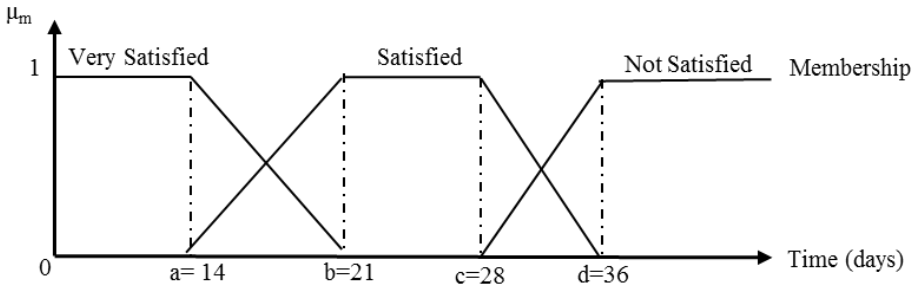


Figure 4-3. An example of trapezoidal functions and fuzzy sets for an estimated measure (procurment time)

4.3.5 Partnership Performance Index (PPI)

The multi-criteria models developed for both partners in the case study are presented in Figure 4-4 and Figure 4-5. Both models compose of four hierarchical stages: 1) partnership performance evaluation, 2) the drivers, 3) the measures, and 4) the partnership performance in different periods that, related to each other by means of conjunctive arrows.

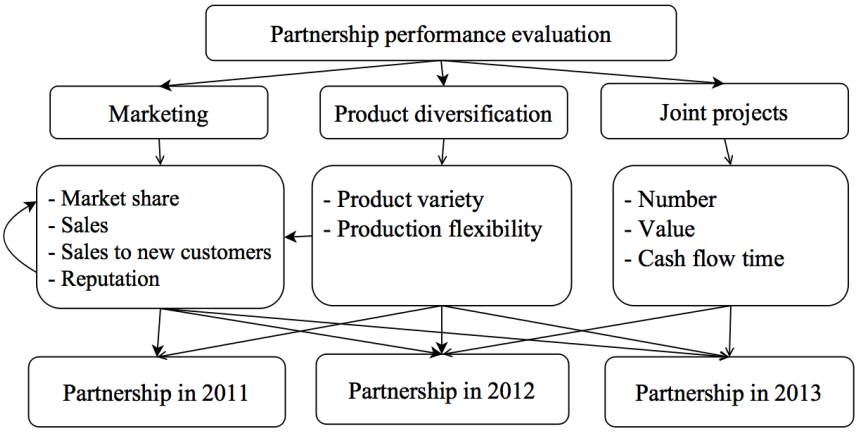


Figure 4-4. The partnership evaluation model for the forest company

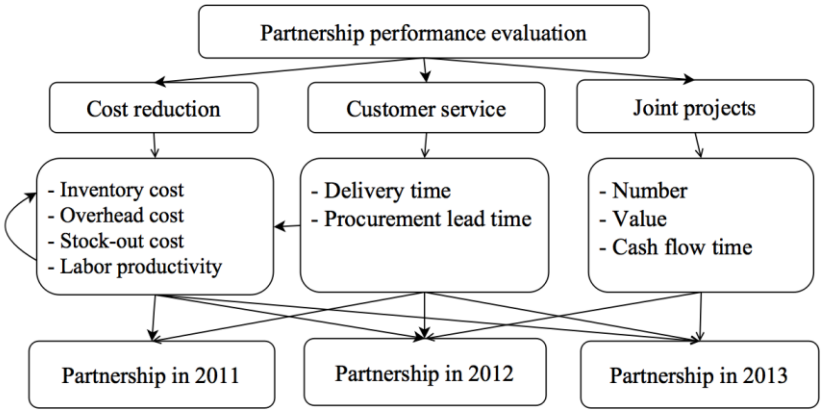


Figure 4-5. The partnership evaluation model for the sawmill

4.4 Results

4.4.1 The interdependency of the drivers and the measures

The results of the ISM analysis revealed additional interdependencies among the measures for company A. However, there was no new interdependencies for measures defined by the sawmill. Table 4-6 shows Reachability Matrix (*M**) with new interdependencies between the measures for the forest company.

Table 4-6. The converged Reachability Matrix after rearrangement for the forest company

	V_{A1}	V_{A2}	V_{A3}	V_{A4}	V_{A5}	V_{A6}	V_{A9}	V_{A7}	V_{A8}
Reputation (V_{A1})	1	1	1	1	0	0	1	0	0
Sales (volume) (V_{A2})	1	1	1	1	0	0	1	0	0
Sales to new customers (V_{A3})	1	1	1	1	0	0	1	0	0
Market share (V_{A4})	1	1	1	1	0	0	1	0	0
Product variety (V_{A5})	1	1	1	1	1	1	1	0	0
Production flexibility (V_{A6})	1	1	1	1	0	0	1	0	0
Cash flow time (V_{A9})	0	0	0	0	0	0	1	0	0
Joint projects (number) (V_{A7})	0	0	0	0	0	0	0	1	0
Joint projects (value) (V_{A8})	0	0	0	0	0	0	0	0	1

4.4.2 The measures' importance and Partnership Performance Index

The final importance of the drivers and the measures for each partner considering all the interdependencies are summarized in Table 4-7 and Table 4-8, respectively. The importance are given for

both initial importance and the final importance. For the forest company, *product diversification* is the most important driver, followed by *marketing* and *joint projects*. In terms of the importance of measures, *product variety, production flexibility*, *reputation* and *value of joint projects* are most important for the forest company.

Table 4-7. The importance of the drivers, the measures and their ranks for the forest company

Driver	Initial	Final	Rank	Measure	Initial	Final	Rank
Marketing (D_{A1})	0.18517	0.08141	2	Reputation (V_{A1})	0.39802	0.04518	3
				Sales (V_{A2})	0.18351	0.02083	6
				Sales to new customer (V_{A2})	0.31394	0.03563	5
				Market share (V_{A4})	0.10454	0.01186	8
Product Diversification (D_{A2})	0.65864	0.28957	1	Product variety (V_{A5})	0.76243	0.26818	1
				Production flexibility (V_{A6})	0.23757	0.08356	2
Joint Projects (D_{A3})	0.15618	0.06866	3	Joint projects (number) (V_{A7})	0.25902	0.01778	7
				Joint projects (value) (V_{A8})	0.63665	0.04371	4
				Cash flow time (V_{A9})	0.10433	0.00716	9

For the sawmill, *cost reduction* is the most important driver of the partnership followed by *customer service* and *joint projects*. *Stock-out cost*, *labor productivity*, *overhead cost*, *inventory cost* are the measures with the highest importance, in ranked order.

Table 4-8. The importance of the drivers, the measures and their ranks for the sawmill

Driver	Initial	Final	Rank	Measure	Initial	Final	Rank
Cost reduction (D_{B1})	0.73064	0.26969	1	Stock-out cost (V_{B3})	0.43248	0.22985	1
				Labor productivity (V_{B4})	0.24581	0.13064	2
				Overhead cost (V_{B2})	0.20581	0.10938	3
				Inventory cost (V_{B1})	0.11590	0.06160	4
Customer service (D_{B2})	0.18839	0.06954	2	Delivery lead time (V_{B6})	0.83333	0.05795	5
				Procurement lead time (V_{B5})	0.16667	0.01159	7
				Joint projects (number) (V_{B7})	0.25829	0.00772	8
Joint Projects (D_{B3})	0.08096	0.02988	3	Total cash flow time (V_{B9})	0.10473	0.00313	9
				Joint projects (value) (V_{B8})	0.63698	0.01904	6

The second output of the model is the Partnership Performance Index (PPI) in different periods. PPI is a single and multi-dimensional index that includes the importance, the interdependencies and the

uncertainties of the measures. Table 4-9 shows the PPIs for the forest company and the sawmill in 2011, 2012 and 2013.

Table 4-9. The Partnership Performance Index (PPI) for the forest company and the sawmill in 2011, 2012 and 2013

	2011	**2012**	**2013**
The forest company	0.2983	0.3570	0.3447
The sawmill	0.3114	0.2923	0.3963

PPIs can be used in two different ways similar to measure importance. First, they can be used to compare partnership in different periods to investigate if the overall performance of partnership has a trend. Second, they can be used to compare the overall PPI for an actual partnership in a specific time with the PPI for the planned values.

4.4.3 Sensitivity analysis and validation

The sensitivity of the PPI was analyzed based on the changes in both the importance and the value of the measures. Figure 4-6 shows the sensitivity of PPI to 20% change in the importance of measures to determine how PPI changes considering their weights and interdependences. As can be seen in Figure 4-6, PPI is more sensitive to measures with higher importance. For example, for the forest company, *product variety* is the most sensitive measure, in which 20% change in *product variety* leads to 10.7% change in the overall performance measure.

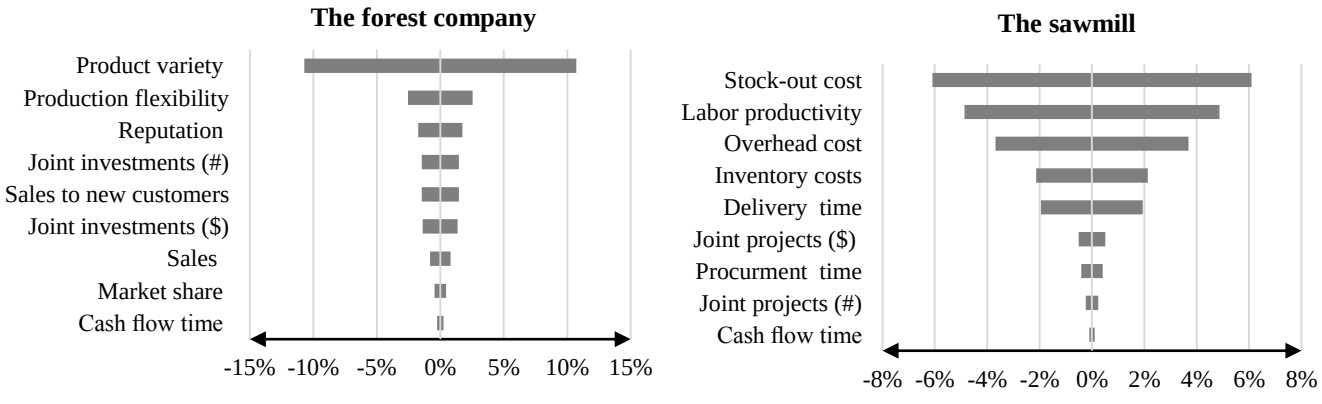


Figure 4-6. Sensitivity of PPI to the importance of the measures for the forest company and the sawmill in 2011

The sensitivity of PPI was analyzed relative to the values of the measures in 2011 for the forest company and the sawmill (Figure 4-7). The results show that *product variety* for the forest company is the most sensitive measure, in which a 20% change in *product variety* changes the overall performance measure by 7.1%. For the sawmill, *stock-out cost* is the most sensitive measure, in which a 20% change in *stock-out cost* results in a 6% change in the overall performance measure.

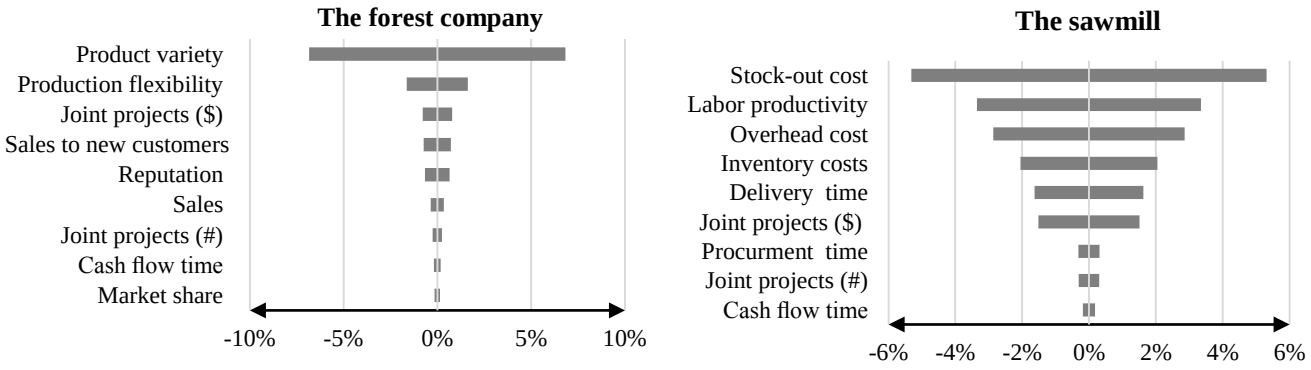


Figure 4-7. Sensitivity of PPI to the values of the measures in 2011 for the forest company and the sawmill

For validation of the results, the managers were asked to rank their drivers and their measures based on their experience, without a priori knowledge of the model's rankings. As can be seen from Table 4-10, the differences between the rankings from the models and those by the mangers are close to each other (maximum difference is two).

Table 4-10. Consistency check of the measures' importance ranking from two different approaches.

The forest company	**Rank**		**The sawmill**	**Rank**	
Measure	**Model**	**Manager**	**Measure**	**Model**	**Manager**
Flexibility	2	2	Inventory cost	4	3
Variety	1	1	Labor productivity	2	4
Reputation	3	4	Overhead cost	3	1
Sales	6	5	Stock-out cost	1	2
Sales to new customer	5	6	Delivery lead time	5	6
Market share	8	9	Procurement lead time	7	5
Cash flow time	9	8	Joint projects (number)	8	9
Joint projects (number)	7	7	Total cash flow time	9	7
Joint projects (value)	4	3	Joint projects (value)	6	8

For performance evaluation, model's results (PPI) for partnership evaluation are compared to the conventional approaches to evaluate partnership performance in the case study. *Sales through partnership* and *gain in market value* are the two major measures for evaluating the partnership from the perspective of the forest company. *Profit (sales - costs)* is the most important evaluation measure for the sawmill. The values of these measures are compared with the results of PPIs for both companies in 2011, 2012 and 2013 (Table 4-11). Since some measures have different units, and also because of the confidentiality issues, all the values are normalized by dividing the value of each year by the sum of the values for three years. In order to make the comparisons easier to interpret, the changes from 2011 to 2012 and 2012 to 2013 are also shown in Table 4-11.

Table 4-11. Different measures to evaluate the partnership performance and their changes over 2011-2013

	Measure	**Normalized values**			**Change**	
		2011	**2012**	**2013**	**2011-2012**	**2012-2013**
The forest company	Sales through partnership ($)	0.31	0.30	0.37	-2.5%	20.3%
	Gain in market value	-0.24	1.99	-0.75	910.4%	-137.5%
	Partnership Performance Index	0.29	0.35	0.34	19.6%	-3.4%
The sawmill	Profit ($)	0.31	0.30	0.38	-3.9%	28.5%
	Partnership Performance Index	0.31	0.29	0.39	-6.1%	35.6

4.5 Discussion and conclusions

The result of the ISM analysis revealed some new interdependencies among measures that would otherwise be overlooked by the mangers. For example, because of new interdependencies, the importance of the *value of the joint projects* decreased by -5.3% while the importance of *production flexibility* increased by 58.5%.

In the second step, ANP was used to get the importance of the drivers and the measures. The number of pairwise comparisons in ANP was reduced significantly by using Incomplete Pairwise Comparison in the PCMs and using quantitative values for evaluating partnerships against the measures in each period.

Verdecho et al. (2012) and Chen & Wu (2010) both considered the importance and interdependencies between the evaluation criteria in their models for the partnership selection stage; however, they did not use any methods to reduce the number of pairwise comparisons. For example, the model proposed by Verdecho et al. (2012) had more than a 1000 comparisons and they completed the comparisons and the structure of the model in eight group sessions, for a total of 25 hours by managers.

The rankings from the proposed models were compared with managers' rankings in order to validate final weights. The difference between the two rankings for the forest company and the sawmill was less than two. For cases with large number of drivers and measures, it would be hard to rank them consistently, while the model provides reliable and consistent ranking because of pairwise comparisons and consistency check. In the proposed model, Fuzzy Logic was used to quantify the uncertain measures that were difficult to estimate from data and were, instead, estimated by the managers.

In order to validate the final results of the proposed model, the rate of change in PPI were compared with that of the other conventional methods (gain in market value and sales through partnership) during 2011-2013. The manager also expressed that the magnitude and direction of the change in *sales through partnership* from 2011 to 2012 were not a good representation of the overall performance of their partnership either. As confirmed by the manager, the changes in PPIs were comprehensive and better representative of the overall partnership performance, considering their joint projects and drivers over 2011-2013. For the sawmill, the changes in the PPIs were more consistent with the changes in the profit over 2011-2013. PPI and Profit ($) decreased -6.9% and -3.9%, respectively, from 2011 to 2012, while they increased by + 35.6% and + 28.5% from 2012 to 2013. This could be explained by the fact that *cost reduction* was the most important driver for the sawmill. Looking at the changes in different measures from 2011 to 2012 revealed that *labor productivity* had the highest change from 2011 to 2012 with 20.1% decrease. This decrease was adjusted by the positive changes in other momentary measures such as *inventory cost (+6.2%)* and *stock-out cost (+4.6%),* and non-momentary measures such as *procurement*

lead time (+15.7) and *cash flow time (+11.4%).* As can be seen in this example, PPI was different from the financial and operational performance measures because it included several measures, their importance and interdependencies.

Partnership performance can be affected by external factors such as market changes and government regulations. Using a single performance measure to evaluate partnership performance could be more prone to the effects of the external factors. For example, if the partnership in the case study was evaluated only by *sales (or gain in market value*) it could be misleading for several reasons. First, *sales* (or *gain in market value)* would be influenced by market changes and it could not provide a comprehensive representation of a partnership's performance, while using a measure for market share can reduce the effect of market changes. In other words, if sales increased only because of the increase in the respected market size, then the market share measure would balance out the change in the market size. Second, *sales* is not the only measure to evaluate partnership drivers. There are several measures such as *reputation* and *sales to new customers* to evaluate the *marketing* driver. Third, the importance of *sales* is different based on the overall drivers of partnership in the case study. Using multiple measures could solve these problems. In the next chapter, the components of partnerships, the factors influencing the performance of an ongoing partnership, is evaluated quantitatively using multiple indicators for each component.

Chapter 5: A decision support model for partnership components evaluation

5.1 Synopsis

Although partnership with other companies could improve companies' performance, partnerships have a high failure rate according to the literature. Therefore, evaluating the components that affect partnership performance quantitatively is as essential as monitoring the performance of a partnership. Joint decision-making, information sharing, risk/reward sharing, relationship-specific assets, trust and commitment are identified as the major components that affect the performance of an ongoing partnership. In this chapter, a multi-criteria decision support model is proposed to evaluate these components. First, partnership components and their indicators are drawn from the literature. Next, the interdependency and importance of the components and their indicators are estimated using Interpretive Structural Modeling and Analytic Network Process (ANP). Finally, the importance of each component and indicator, and a single number for the overall level of partnership components in each period, named as Partnership Component Index (PCI), as the major outputs of the models, are analyzed and discussed.

5.2 Partnership components

Studies show that the main components influencing partnership performance are similar in all partnerships, however, their intensity and indicators could vary among different types of partnership (Lambert et al., 1996; Simatupang and Sridharan, 2005; Arshinder et al., 2008). Information sharing, joint decision-making, relationship-specific assets, risk/reward sharing, trust and commitment have been identified as the major components (Simatupang and Sridharan, 2005; Arshinder et al., 2008). In this study, trust and commitment are not incorporated to the modeling process because several review studies concluded that there was no consensus on the operational indicators of trust and commitment (Goodman and Dion, 2001; Stephen James Kelly, 2004; Seppänen et al., 2007; Laeequddin et al., 2010; McEvily and

Tortoriello, 2011). In addition, the results of the survey in Chapter 3 show trust and commitment are mediator variables rather than independent variables. Information sharing, joint decision-making, relationship-specific assets, and risk/reward sharing are considered as components of partnership performance in operational models (Simatupang and Sridharan, 2005; Arshinder et al., 2008). Simatupang and Sridharan (2005) found a positive correlation between collaboration performance and partnership components in a survey of 73 companies in New Zealand. Similarly, in the survey of 46 forest companies in British Columbia, Canada in this research, there was a strong positive correlation between partnership components and partnership performance. In the following section, each component is explained in detail.

Information sharing is defined as the formal and informal sharing of relevant, reliable and timely information between partners (Ramanathan, 2013) and is characterized by content, reliability, accuracy and frequency of information (Neumann and Segev, 1979). Information shared between partners can be related to operational, tactical and strategic plans and decisions (Lambert et al., 1996; Huang et al., 2003). The type of shared information depends on the type of partnership. In a supplier-buyer partnership, sharing timely information about customer orders and demand forecasts helped companies in reducing their inventory and stock-out costs and lead time (Bourland et al., 1996; Reddy and Rajendran, 2005). In another study, Yu et al. (2010) found the positive effects of sharing capacity, demand and inventory information on the inventory level, stock-out costs, production and transportation lead times, and customers demand in partnerships between retailers and manufacturers.

Joint decision-making refers to joint planning that ranges from operational to strategic planning (Lambert et al., 1996; Simatupang and Sridharan, 2005; Arshinder et al., 2008). Decisions about pricing, promotion policies, scheduling, inventory, etc. could be done jointly by partners. Primo and Amundson (2002) found a positive influence of suppliers' involvement in decision-making on product quality, project development time and project cost in developing a new product in 38 joint projects in the electronics industry.

Risk/reward sharing refers to the processes for aligning partners' incentives by sharing costs, risks, and rewards in the form of contracts and agreements. Risk/reward sharing in partnership is identified as a critical factor influencing partnership performance (Lambert et al., 1996; Simatupang and Sridharan, 2005; Sodhi and Son, 2009). Risks can be classified into four main categories: 1) external risks caused by change in the respective market or financial system, 2) operational risks associated with the operational and administrative procedures of the particular business, 3) legal risks associated with the change in the rules and regulations, and 4) other risks such as natural disasters (floods or fire) (Jolly, 2003). The lack of agreement on the mechanisms of sharing risk/reward was one of the main reasons for non-collaborative relationships with other companies in supply chain (Narayanan and Raman, 2004). Not all the risk/reward shared between partners are equally sharable, such as the time saved in partnership in transportation, or measurable, such as the reputation gained from a partnership in marketing, thus the sociological indicator of "tolerance for unequal short-term losses/gains in favor of long-term mutual benefits" was suggested by Lambert et al. (Lambert et al., 1996) to capture this dimension.

Relationship-specific assets are assets dedicated to a specific relationship, whose redeployment entails considerable switching costs (Geyskens et al., 2006). Dyer (1996) investigated the extent to which performance variations in supplier-customer relationships were explained by the differences in relationship-specific assets using case studies of Japanese and U.S automakers. His findings indicated a positive influence of relationship-specific assets (human, IT and site assets) on the performance (quality, inventory costs, and the time required to develop new products).

Previous empirical studies evaluated the partnership components using subjective measures by asking respondents about the intensity of each component in the surveyed companies (e.g. Fontenot and Wilson, 1997; Glaister and Buckley, 1998; Vlosky et al., 1998; Simatupang and Sridharan, 2005). However, from an operational point of view, it is critical to evaluate the intensity of partnership components in different

time periods in order to improve the performance (Arshinder et al., 2008). Table 5-1 shows a summary of the major components influencing the partnership performance.

Table 5-1. The major components influencing the partnership performance

Component	Subcomponent	Indicator	Example of related studies
Information Sharing (IS)	- Operational - Tactical and strategic	Frequency of information sharing	(Brinkerhoff, 2002; Hoffmann and Schlosser, 2001; Lambert et al., 1996; Maloni and Benton, 1997; Spekman et al., 1998)
Joint Decision-making (JD)	- Operational - Tactical and strategic	Percentage of decisions made jointly	(Lambert et al., 1996; Spekman et al., 1998; Brinkerhoff, 2002; Verdecho et al., 2012)
Risk/reward Sharing (RS)	- Sharing mechanisms - Tolerance for unequal sharing	Percentage of risk/reward shared equally	(Chen and Wu, 2010; Lambert et al., 1996; Sodhi and Son, 2009)
Relationship-specific Assets (RA)	- Personnel exchange/training - Assets for ICT solutions - Non-IT and non-human assets	- Man/day - Monetary value - Monetary value	(Beach et al., 2005; Brinkerhoff, 2002; Hoffmann and Schlosser, 2001; Kim et al., 2010; Lambert et al., 1996; Sodhi and Son, 2009; Verdecho et al., 2012)

5.3 Modeling approach

The modeling approach in this chapter is similar to the steps for partnership performance evaluation explained in Chapter 4 except for the fuzzy step. Therefore, mathematical details are not repeated. In this model, fuzzy is not used because the indicators are not defined in interval sets. In this study, partnership components and their indicators are drawn from several theoretical and empirical studies. Decision-makers could select from the identified components and indicators or add their specific ones. The modeling approach has five steps and has to be performed jointly by the partners: 1) define the partnership components and their indicators, 2) determine the interdependencies between partnership components and their indicators, 3) estimate the importance of the components and the indicators 4) quantify and normalize the indicators of partnership components in different periods, and 5) calculate the final importance of the components and their indicators and the overall Partnership Component Index (PCI).

The multi-criteria model is schematically presented in Figure 5-1. The top level of the proposed model presents the objective of the model, which is to evaluate the partnership components. The second and third levels include the criteria (components/subcomponents) and sub-criteria (indicators) of the partnership. The lowest level consists of the alternatives, which are the partnership in different periods.

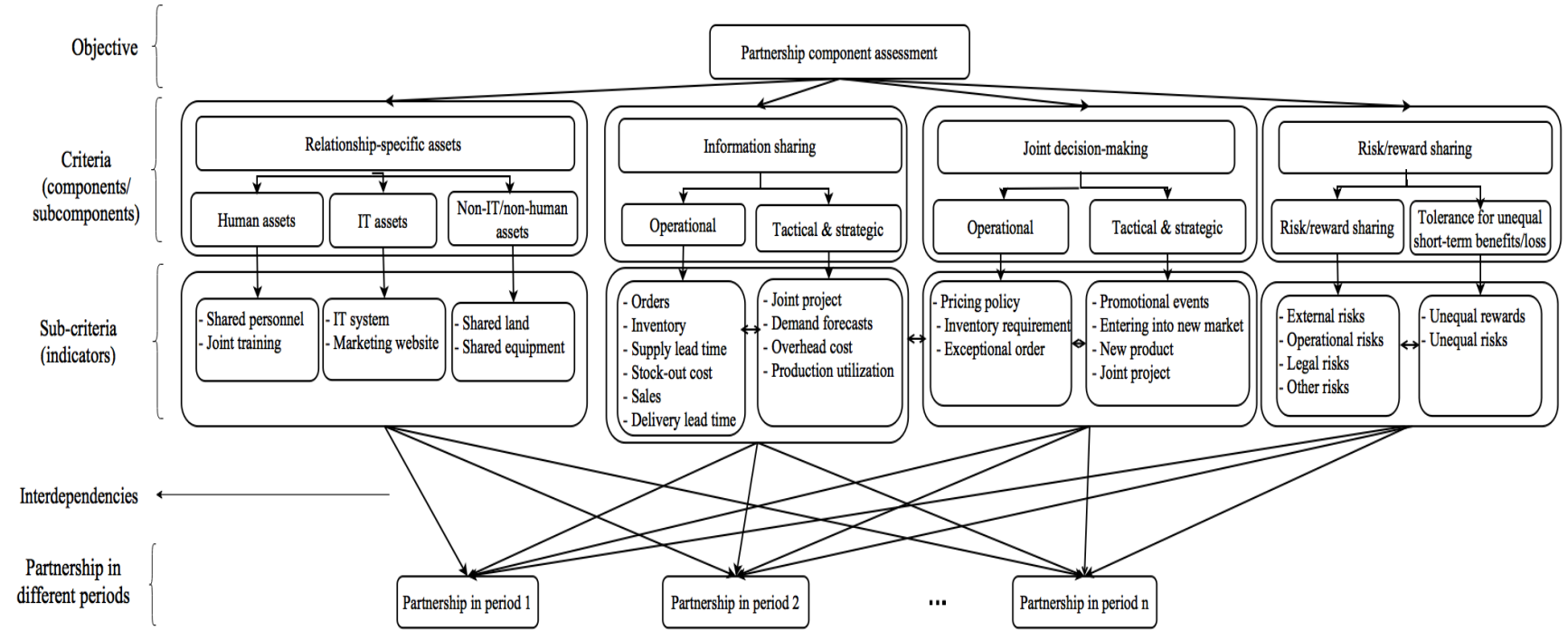


Figure 5-1. The proposed multi-criteria model for evaluating the components of an ongoing partnership in different periods

In the proposed modeling approach, Interpretive Structural Modeling is used to determine the interdependencies among the indicators (Warren, 1975) and ANP is used to estimate the importance of the components and indicators considering the interdependencies among the indicators (Saaty, 2008). Furthermore, Incomplete Pairwise Comparison (IPC) is used (Harker 1987) to reduce the large number of pairwise comparisons in ANP required from the decision-makers. IPC is simple and validated by other studies (Carmone Jr et al., 1997; Setiawan, 2002).

The indicators' values can be in different units or with different intervals as opposed to the values resulted from pairwise comparisons (Saaty, 2005). Therefore, the indicators should be normalized so that the intervals are similar and arithmetic mathematics can be applied (Dawood, 2011).

Finally, Partnership Component Index (PCI), presented in equation (5.1), is calculated using the weighted sum of the quantified and normalized values of indicators. Each indicator is normalized between [0-1] using Min-Max normalization (Tabachnick et al., 2001) method, in period (t) multiplied by the final importance of the indicators:

$$PCI(t) = \sum_{i=1}^{n} w_i * x'_{ti} \tag{5.1}$$

Where w_i is the final importance of indicator (i) and x'_{ti} is the normalized value of the indicator i in period t. PCI is a quantitative index that captures all the indicators related to partnership components and their importance.

5.4 Applying the model to the case study

The developed model in this chapter is applied to the same case study presented in Section 4.3 in Chapter 4. The general managers of the two companies are the decision-makers.

5.4.1 Defining partnership components and their indicators

The managers of both companies in the case study were asked to select the relevant indicators for each component and the most convenient way to estimate the indicators. If their indicators were not in the provided list, they were asked to define their indicators. Below each component is explained in the context of the case study, followed by subcomponents, and their indicators.

5.4.1.1 Information sharing

In this case study, both partners share operational and strategic information by face-to-face, phone and electronic communication. The managers of the companies talk daily on the phone about operational issues such as those related to transportation, inventory, and orders. Table 5-2 shows the indicators of the information sharing component for the case study.

The information type was grouped into different operational, tactical and strategic levels to capture the content. Reliability and accuracy are not considered in this case because both partners have access to each other's information, thus it was assumed partners share the most reliable and accurate information possible. Information frequency was used as the indicator to evaluate information sharing. The interval for frequency depends on the type of information. For example, the frequency of sharing information can range from real time to yearly exchange. The tactical and strategic information can be shared with lower frequency. In this case study, the frequency of sharing information is suggested by the mangers from real time to monthly for exchange of operational information and from monthly to yearly for tactical and strategic information. Daily intervals for operational information were used. For tactical and strategic information, monthly intervals were used.

Table 5-2. The indicators for information sharing in the case study

Component	Subcomponent	Indicator
Information Sharing (IS)	Operational	IS (1): Frequency of sharing information about orders IS (2): Frequency of sharing information about inventory IS (3): Frequency of sharing information about supply lead time IS (4): Frequency of sharing information about stock-out cost IS (5): Frequency of sharing information about sales IS (6): Frequency of sharing information about delivery lead time IS (7): Frequency of sharing information about cash flow times from customers IS (8): Frequency of sharing information about transportation/delivery schedule IS (9): Frequency of sharing information about complaints from customers
	Tactical & Strategic	IS (10): Frequency of sharing information about joint projects IS (11): Frequency of sharing information about demand forecasts IS (12): Frequency of sharing information about overhead cost IS (13): Frequency of sharing information about production utilization IS (14): Frequency of sharing information about partners' drivers/ measures

5.4.1.2 Joint decision-making

Besides information sharing, the partners jointly make decisions at different levels. At the operational level, partners jointly make decisions about pricing policy, inventory requirements and exceptional orders. At the strategic level, the partners jointly make decisions about new projects or entering into new markets. Table 5-3 shows different areas that the case study partners listed as the potential areas for joint decision-making. The managers were asked to evaluate the extent in which they decide jointly about each indicator from 0-100%, with 10% intervals.

Table 5-3. The indicators for joint decision-making in the case study

Component	Subcomponent	Indicator
Joint decision-making (JD)	Operational	JD (1): Extent of joint decision-making regarding pricing policy JD (2): Extent of joint decision-making regarding inventory requirement JD (3): Extent of joint decision-making regarding exceptional orders
	Tactical & strategic	JD (4): Extent of joint decision-making regarding promotional events for clients JD (5): Extent of joint decision-making regarding entering into new market JD (6): Extent of joint decision-making regarding new product

Component	Subcomponent	Indicator
		JD (7): Extent of joint decision-making regarding joint project/investment

5.4.1.3 Risk/reward sharing

Risk/reward sharing has evolved over time in the considered partnership. In 2004, when the partners started the partnership, they had a flat fee contract, in which the forest company received a fixed percentage more than the market value for the logs used by the sawmill. However, based on managers' experience, this contract did not give both partners strong incentives to increase their sales. As a result, they switched to a profit sharing contract, in which they shared the profits after deducting the contributed expenses of each partner. Under this contract, they did not have the incentive to reduce their costs. Currently, they have a revenue sharing contract. Through the revenue sharing mechanism, both partners have an incentive to increase their sales, and to decrease their costs in order to get more profit. A loose and open-ended contract was signed by partners in which the time frame of partnership, volume of logs and the scope of partnership were not mentioned.

In the considered partnership, the forest company manages the inventory cost. The sawmill costs are mostly variable costs. This way, they share the fluctuation in the upstream side because of natural forest issues and downstream side because of the market fluctuations. Table 5-4 shows risk/reward sharing indicators in the case study. The risk/reward sharing was evaluated in percentage (0-100%, with 10% intervals), in which 100% assigned to the situation where all of the risks/rewards are shared equally between both partners and 0% where the risk is not shared between partners. For the second sub-component, the interval was defined between 0, when there is no tolerance for unequal short-term losses/benefits, and 100%, when partners can tolerate the unequal short-term losses/benefits.

Table 5-4. The indicators for risk/reward sharing in the case study

Component	Subcomponent	Indicator
Risk/reward sharing (RS)	Contracts/agreements	RS (1): Percentage of sharing external risks RS (2): Percentage of sharing operational risks RS (3): Percentage of sharing legal risks RS (4): Percentage of sharing other risks (e.g. natural disasters)
	Tolerance for short-term unequal risk/reward in favor of long-term mutual benefits	RS (1): Tolerance for unequal risks RS (2): Tolerance for unequal rewards

5.4.1.4 Relationship-specific assets

The forest company provided the land for the facilities of the sawmill company. Major parts of their IT systems and website are jointly managed. They also share personnel, as needed. Table 5-5 shows different subcomponents and indicators of relationship-specific assets. Human assets are estimated by man-days, while IT assets, non-human and non-IT resources are estimated using dollar values as suggested by Dyer (1996).

Table 5-5. The indicators for relationship-specific assets in the case study

Component	Subcomponent	Indicator
Relationship-specific assets (RA)	Human assets	RA (1): Man-day shared personnel RA (2): Man-day joint training
	IT assets	RA (3): Investment in joint IT system RA (4): Investment in joint marketing website
	Non-human and non-IT resources	RA (5): Value of shared land RA (6): Value of shared equipment

5.5 Results

5.5.1 The interdependencies of the components and the indicators

Managers of the forest company and the sawmill agreed that the only significant interdependency was between information sharing and joint decision-making components. This is consistent with the results of the survey of 46 forest companies in British Columbia, Canada in the first phase of this study (Chapter 3), in which a strong correlation between information sharing and joint decision-making was found. Therefore, only the direct interdependencies (adjacency matrix)

of the indicators of these two components were formed, in which an entry (i,j) is 1, if the variable in row (i) is only under direct influence of the variable in column (j). Using Interpretive Structural Modeling (Warren, 1975), reachability matrix of the interdependencies was found. The reachability matrix for the case study revealed that there were two more interdependencies among the indicators based on the initial interdependencies defined by the managers in the adjacency matrix. Table 5-6 shows the reachability matrix with new interdependencies between the indicators. In Table 5-6, an entry (i,j) is 1, if the variable in row (i) is reachable (direct/indirect influence) by the variable in column (j), otherwise the entry value is 0.

Table 5-6. Reachability matrix with new interdependencies between the indicators

i \ j	IS (1)	IS (2)	IS (3)	IS (4)	IS (5)	IS (6)	IS (7)	IS (8)	IS (9)	IS (10)	IS (11)	IS (12)	IS (13)	IS (14)	JD (1)	JD (2)	JD (3)	JD (4)	JD (5)	JD (6)	JD (7)
IS (1)	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
IS (2)	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1
IS (3)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
IS (4)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
IS (5)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0
IS (6)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0
IS (7)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1
IS (8)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
IS (9)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
IS (10)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1
IS (11)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
IS (12)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
IS (13)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1
IS (14)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
JD (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
JD (2)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
JD (3)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
JD (4)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
JD (5)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
JD (6)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
JD (7)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

5.5.2 The indicators' importance and Partnership Component Index

The final importance of the partnership components and subcomponents for the case study, considering all the interdependencies, are summarized in Table 5-7. The indicators with the same

weights have the same ranks. In the model, the number of pairwise comparisons needed to estimate the weights were reduced by using Incomplete Pairwise Comparison in the PCMs and using quantitative values for evaluating partnerships against the indicators in each period.

The results show that *relationship-specific assets* is the most important component followed by *risk/reward sharing, information sharing* and *joint decision-making*. In terms of the importance of subcomponents, *shared land and equipment, risk/reward sharing mechanism,* and sharing *operational* and *tactical and strategic information* are the most important subcomponents.

Table 5-7. The importance and ranks of the partnership components and their subcomponents

Component	Weight	Rank	Subcomponent	Weight	Rank
Information Sharing (IS)	0.22344	3	Operational information	0.11172	3
			Tactical & Strategic information	0.11172	3
Joint Decision-making (JD)	0.09557	4	Operational decisions	0.02389	7
			Tactical & strategic decisions	0.07168	5
Risk/reward Sharing (RS)	0.28671	2	Risk/reward sharing mechanism	0.21503	2
			Tolerance for unequal risk/reward	0.07168	5
Relationship-specific Assets (RA)	0.39428	1	Shared Human assets	0.10184	4
			Shared IT assets	0.04129	6
			Shared land and equipment assets	0.25115	1

The importance and the rank of the indicators are shown in Table 5-8. Percentage of sharing *external risks* is the most important indicator followed by the values of *shared land and shared equipment*.

Table 5-8. The ranking of indicators in the components and indicators levels

Component	Indicator	Weight	Rank in the component	Overall rank
Information Sharing (IS)	IS (1): Frequency of sharing information about orders	0.00806	3	12
	IS (2): Frequency of sharing information about inventory	0.00736	4	13
	IS (3): Frequency of sharing information about supply lead time	0.00609	5	16
	IS (4): Frequency of sharing information about stock-out cost	0.00369	9	24
	IS (5): Frequency of sharing information about sales	0.00264	11	29
	IS (6): Frequency of sharing information about delivery lead time	0.00127	14	33
	IS (7): Frequency of sharing information about cash flow times from customers	0.00198	12	30
	IS (8): Frequency of sharing information about transportation/delivery schedule	0.00157	13	32

Component	Indicator	Weight	Rank in the component	Overall rank
	IS (9): Frequency of sharing information about complaints from customers	0.00458	8	20
	IS (10): Frequency of sharing information about joint projects	0.01073	2	9
	IS (11): Frequency of sharing information about demand forecasts	0.01319	1	8
	IS (12): Frequency of sharing information about overhead cost	0.00344	10	25
	IS (13): Frequency of sharing information about production utilization	0.00528	6	18
	IS (14): Frequency of sharing information about partners' targeted drivers/ measures	0.00460	7	19
Joint Decision-making (JD)	JD (1): Extent of joint decision-making regarding pricing policy	0.00266	4	26
	JD (2): Extent of joint decision-making regarding inventory requirement	0.00266	4	26
	JD (3): Extent of joint decision-making regarding exceptional orders	0.00266	4	26
	JD (4): Extent of joint decision-making regarding promotional events for clients	0.00387	3	23
	JD (5): Extent of joint decision-making regarding entering into new market	0.00168	5	31
	JD (6): Extent of joint decision-making regarding new product	0.00868	2	11
	JD (7): Extent of joint decision-making regarding joint project/investment	0.00967	1	10
Risk/reward Sharing (RS)	RS (1): Percentage of sharing external risks	0.04642	1	1
	RS (2): Percentage of sharing operational risks	0.01530	3	7
	RS (3): Percentage of sharing legal risks	0.00451	5	21
	RS (4): Percentage of sharing other risks (e.g. natural disasters)	0.00546	4	17
	RS (5): Tolerance for unequal risks	0.01991	2	4
	RS (6): Tolerance for unequal rewards	0.00398	6	22
Relationship-specific Assets (RA)	RA (1): Man-days shared personnel	0.01697	2	5
	RA (2): Man-days joint training	0.01697	2	5
	RA (3): Investment in joint IT system	0.00688	3	14
	RA (4): Investment on joint marketing website	0.00688	3	14
	RA (5): Value of shared land	0.04186	1	2
	RA (6): Value of shared equipment	0.04186	1	2

The second output of the model is Partnership Component Index (PCI) in different periods. PCI is a single and multi-dimensional index that includes the importance, the interdependencies of the components and the indicators. Table 5-9 shows the PCIs for the case partnership in 2011, 2012 and 2013.

Table 5-9. The Partnership Component Index (PCI) for the case study in 2011, 2012 and 2013

	2011	2012	2013
Partnership Component Index	0.1771	0.1902	0.1993
Percentage change from previous year		7.41%	4.77%

5.5.3 Sensitivity analysis and validation

The sensitivity of the PCIs was analyzed based on the changes in both the indicators' importance and the value of the indicators. Figure 5-2 shows the five most sensitive indicators. As seen in Figure 5-2, PCI is more sensitive to the percentage of *Shared land* from relationship specific assets, in which 20% change in *Shared land* leads to 8.27% change in the overall Partnership Component Index (PCI). *Sharing external risks* is the second most sensitive indicator of all partnership component indicators, followed *by value of shared equipment*, *tolerance for short-term unequal losses*, and *sharing operational risks*.

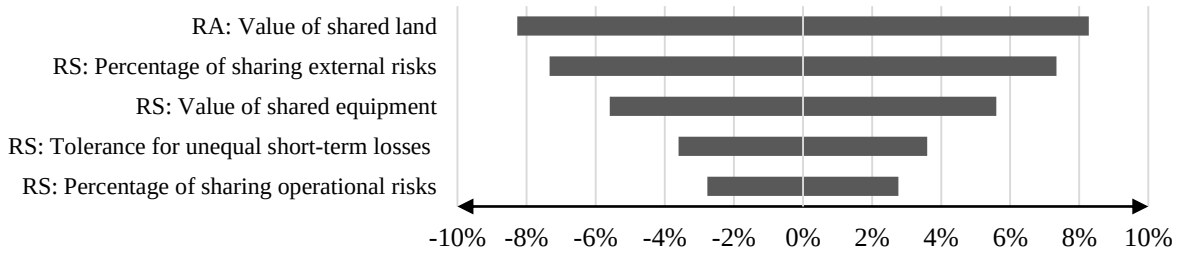


Figure 5-2. Sensitivity of PCI to the values of the five most sensitive indicators for the case study partnership in 2011

The sensitivity of PCI to the importance of the indicators in 2011 was also analyzed for the considered partnership (Figure 5-3). Figure 5-3 shows the sensitivity of PCIs to a 20% change in the importance of indicators.

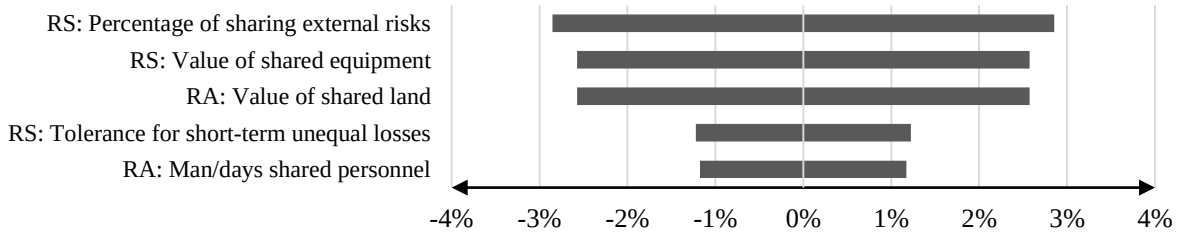


Figure 5-3. Sensitivity of PCI to the importance of the five most sensitive indicators for the case study partnership

The sensitively analyses show that *external risks, shared land* and *equipment, tolerance for short-term unequal loses, sharing personnel and joint training* are the most important indicators of components in this partnership.

For validation of the results, the managers were asked to rank the partnership components and the subcomponents based on their experiences, without the knowledge of the model's rankings. As can be seen from Table 5-10, there is no difference for the components' rankings and subcomponents rankings from the models and those by the managers are close to each other.

Table 5-10 Consistency check of the components and subcomponents importance ranking from two different approaches.

Component	**Model**	**Manager**	**Subcomponent**	**Model**	**Manager**
Information Sharing (IS)	3	3	Operational	3	2
			Tactical & Strategic	3	4
Joint Decision-making (JD)	4	4	Operational	7	7
			Tactical & strategic	5	5
Risk/reward Sharing (RS)	2	2	Risk/reward sharing mechanism	2	2
			Tolerance for unequal risk/reward	5	3
Relationship-specific Assets (RA)	1	1	Human assets	4	6
			IT assets	6	8
			Land and Equipment	1	1

In order to compare the rankings of the indicators, the managers found it hard to rank 33 indicators of partnership components. Thus, the indicators were categorized into three clusters in terms of their importance: high, medium or low. The important indicators account for 50%, the medium importance indicators account for 30% and the low importance indicators account for 20% of the total weights. These cut-off values were suggested and tested by Verdecho et al., (2012) and there were accepted by the managers in the case study. The results (Table 5-11) show that 76% of categorization are compatible.

Table 5-11. The clustering of the indicators by the models and the managers

Component	Indicator	Model	Manager
Information Sharing (IS)	IS (1): Order	M	H
	IS (2): Inventory	M	M
	IS (3): Supply lead time	M	M
	IS (4): Stock-out cost	L	L
	IS (5): Sales	L	M
	IS (6): Delivery lead time	L	L
	IS (7): Cash flow times from customers	L	L
	IS (8): Transportation/delivery schedule	L	L
	IS (9): Complaints from customers	L	L
	IS (10): Joint project	M	M
	IS (11): Demand forecast	M	H
	IS (12): Overhead cost	L	L
	IS (13): Production utilization	L	M
	IS (14): Partners' targeted drivers/ measures	L	L
Joint Decision-Making (JD)	JD (1): Pricing policy	L	L
	JD (2): Inventory requirement	L	L
	JD (3): Exceptional order	L	L
	JD (4): Promotional events for clients	L	L
	JD (5): Entering into new market	L	L
	JD (6): New product	M	M
	JD (7): Joint project/investment	M	H
Risk/reward Sharing (RS)	RS (1): External risks	H	H
	RS (2): Operational risks	M	H
	RS (3): Legal risks	L	L
	RS (4): Other risks (natural, ..)	M	M
	RS (1): Tolerance for unequal risks	H	H
	RS (2): Tolerance for unequal rewards	L	M
Relationship-specific Assets (RA)	RA (1): Sharing personnel	H	H
	RA (2): Joint personnel training	H	M
	RA (3): Shared IT system	M	M
	RA (4): Shared marketing website	M	M
	RA (5): Shared land	H	H
	RA (6): Shared equipment	H	H

The results of the model for Partnership Component Index (PCI) are compared against the Partnership Performance Index (PPI) developed in Chapter 4 for the same case study. Although there are positive correlation between PCI and PPI (shown in Figure 5-4), it is impossible to generalize this correlation over time in this case by using statistical tools because of the limited data points and the high number of indicators. In order to make the comparisons easier, the percentage of changes for PPSs and PCIs from 2011 to 2012 and from 2012 to 2013 are shown in Table 5-12 as well.

Table 5-12. The average Partnership Performance Index (PPI) for the forest company and sawmill vs Partnership Component Index (PCI) in 2011, 2012 and 2013

Index	2011	2012	2013
PPI values	0.30485	0.32465	0.3705
PPI percentage change from previous year		6.49%	14.12%
PCI values	0.1771	0.1902	0.1993
PCI percentage change from previous year		7.41%	4.77%

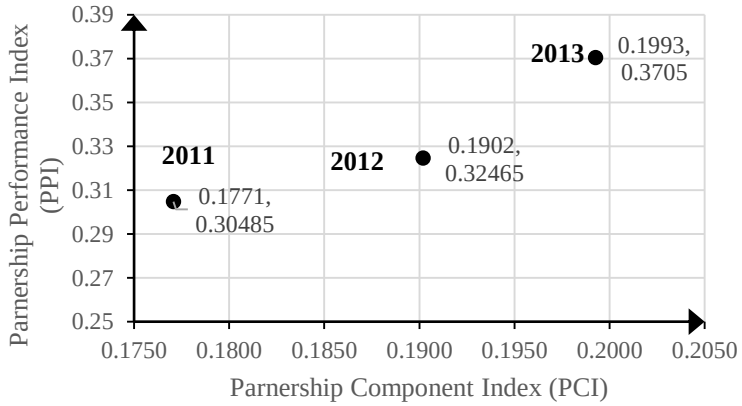


Figure 5-4. Partnership Performance Index (PPI) vs Partnership Component Index (PCI) for the case study in 2011, 2012 and 2013

5.6 Discussion and conclusions

In this chapter, a comprehensive and systematic approach to assess the components of an ongoing partnership was presented. The proposed model aims to fill a gap in the literature for a single multi-dimensional measure (index) to assess partnership components considering the importance and the interdependencies of components and their indicators.

In this case study, the "Percentage of sharing external risks" and "Shared land and equipment assets" are identified as the most important indicators of the partnership components. Both, the forest company and the sawmill operate in volatile markets with low marginal profit; therefore, sharing the external risks is the most important indicator. It was shown before that the lack of

agreement on risk/reward sharing mechanisms was the main reason for collaboration failure of eight Swedish forest companies (Frisk et al., 2010).

The intensity of shared capital assets (shared land and equipment) in the case study is an important indicator of the overall intensity of the partnership components because both companies are primary forest products and capital-intensive companies. .

The risk/reward sharing mechanism in this case has evolved to a revenue-sharing mechanism. Cachon and Lariviere (2005) found that the revenue-sharing contract coordinates incentive in supply chain partnership with a single partner better than other contracts (e.g. franchise, quantity discount and price-discount contracts). The contract in the case study has a loose and open-ended style. This is consistent with the results of Lambert et al. (1996) from 18 partnerships, in which they found that the strongest partnerships generally have the shortest and least specific agreements.

The proposed multi-criteria model incorporates the four major partnership's components and their importance and interdependencies which were overlooked in previous models (Lambert et al., 1996; Simatupang and Sridharan, 2005).

From a practical perspective, the managers in the considered case study found that the beneficial results of the models were not only in rankings and PCIs values, but also the process that led to a complete discussion of all the important components and indicators. This modeling approach helped them to clarify and communicate partnership components and their indicators and consider a way for estimating the value of each indicator. The advantage of model's ranking is that it quantifies the importance, so it can be used later to aggregate the indicators using their weights and values and it also provides reliable and consistent ranking because of pairwise comparisons and consistency check. The weights (rankings) resulted from the proposed model could be used for other managerial purposes such as resource allocations depending on the priority of components

and indicators. The proposed modeling approach is applicable to other types of partnerships; however, modifications to the considered indicators may be required based on the industry context.

Chapter 6: Conclusions, limitations and future research

6.1 Conclusions

Conclusions are divided into two main sections: 1) conclusions for the survey of the forest products companies in British Columbia, and 2) conclusions for the two multi-criteria decision support tools for evaluating partnership performance and components.

For the first part, in order to establish new partnerships and improve the existing ones in the forest products supply chain, identifying the existing and potential partnering practices is essential. Despite the fact that there were some single/multiple cases or survey studies in the forest industry on partnering practices, there were a few studies on different existing and potential partnerships (the types and drivers) in this sector in British Columbia.

In this thesis, the factors influencing partnerships were investigated in the context of the forest industry in BC using a survey of companies. The questions in the survey were divided into two sections: 1) the types of partners, and the importance of different partnership drivers, and 2) the importance of the factors influencing partnership performance. These factors included: symmetry, compatibility, mutuality, joint decision-making, information sharing, risk/reward sharing, relationship-specific assets, trust and commitment. The drivers included: cost reduction, marketing, product diversification and development, and customer service improvement. A survey of 46 forest products companies was conducted.

The survey's results showed that the most common existing partnership was a partnership with suppliers (56%), while the least common partnership was a community-based partnership (11%). Customer service improvement, cost reduction and product diversification were the most important drivers for establishing new partnerships.

The results of correlation analysis showed that, except for symmetry and compatibility, all the other factors were correlated to the partnership performance. However, the results of regression analysis indicated that the degree of joint decision-making, relationship-specific assets, and risk/reward sharing were the best predictors of the performance in the surveyed companies.

From a theoretical perspective, in all the previous survey studies, some factors were overlooked. For example, some studies overlooked risks/reward sharing (e.g. Ellram, 1995; Sodhi and Son, 2009), while others did not consider relationship-specific assets (e.g. Hoffmann and Schlosser, 2001; Verdecho et al., 2012). Not only were the investigated factors different in previous studies, but also different indicators were used to measure similar factors. Some factors such as trust and commitment are difficult to define and measure in the context of inter-firm relationships. Most previous survey studies tried to capture different dimensions of trust and commitment by using multiple items, while several review studies concluded that there was no consensus on the operational indicators of trust and commitment (Goodman and Dion, 2001; Stephen James Kelly, 2004; Seppänen et al., 2007; Laeequddin et al., 2010; McEvily and Tortoriello, 2011). For example, McEvily and Tortoriello (2011) identified 129 different measures of trust by analyzing 171 papers published on trust measures/indicators over 48 years. Lambert et al., (1996) in their in-depth interviews of the executives in 18 inter-firm relationships in the US realized that most executives involved in partnerships found it difficult to precisely define trust and commitment, however, they all intuitively knew when it existed. Therefor in this study, respondent managers were asked about the level of trust and commitment which existed in their successful partnership without limiting the dimensions of these factors with a limited number of items.

Another difference in the survey was that correlation between factors, and their possible mediation effects were considered, while these were often overlooked in previous studies (e.g. Ellram, 1995; Hoffmann and Schlosser, 2001; Sodhi and Son, 2009). Studies focusing on causality

found that some factors especially trust and commitment were mediators between other influencing factors and partnership performance (Kwon and Suh, 2005; Morgan and Hunt, 1994; Wu et al., 2004). For example, Sodhi and Son (2009) found trust as the most important predictor for partnership performance in a survey of supplier-buyer relationship in the retail industry, however, they overlooked the high correlation between trust and commitment and other factors in their data, therefore, they did not investigate the mediation effects of trust on the relationship between partnership performance and other factors. In this thesis, trust and commitment were found to be correlated to partnership performance of the surveyed forest companies. Nevertheless, after investigating the mediation effect of trust and commitment based on previous studies on causality (Morgan and Hunt, 1994; Wu et al., 2004; Kwon and Suh, 2005), trust was found an antecedent for commitment, and both were found to be as mediators between other factors (information sharing, joint decision-making and relationship-specific assets) and partnership performance.

The positive influence of information sharing, joint decision-making and relationship-specific assets on several partnership performance measures has been found in other studies (Burkert et al., 2012; Chang et al., 2012; Handfield and Bechtel, 2002). However, to the best of author's knowledge, there is no survey study that considers risk/reward sharing as an independent factor influencing partnership performance along with the factors from other theories of inter-firm relationships. In this thesis, risk/reward sharing and relationship-specific assets were not evaluated by the respondents as the top three important factors existing in the successful partnerships, however, they were among the top three factors explaining the performance variations of those partnerships. Handfield and Bechtel (2002) found the indirect influence of risk/reward sharing mechanisms (contracts) on the performance of supply chain partnership (responsiveness) through trust, but they did not investigate its direct influence on the performance, and thus concluded there was no significant direct influence. On the contrary, in another study, Poppo and Zenger (2002)

found that risk/reward sharing mechanism (e.g. contracts) and trust both independently and positively influenced partnership performance using data from a sample of partnerships in the IT industry.

The lack of agreement on the mechanisms of sharing risk/reward is one of the main reasons for non-collaborative relationships with companies in supply chains (Narayanan and Raman, 2004). Even when companies realize that partnerships are more beneficial than transactional relationships, they avoid partnerships if either or both firms consider the risk/reward sharing mechanisms unfair (Katok and Pavlov, 2013). Sharing risk/reward has been shown extensively to be a cause of non-collaborative behaviors in inter-personal relationships using different theories such as game theory, evolutionary psychology and social theories (Almenberg et al., 2013). In inter-firm relationships, decision-makers from both partners define the level of the components in a partnership, which at the core is a form of inter-personal relationship. Hence, it is necessary to jointly define and agree on the mechanisms to share benefits, risks and costs between partners in inter-firm relationships. However, all the risks/rewards are not measurable and equally sharable in a partnership, such as the reputation gained from a partnership in marketing, thus the sociological indicator of "tolerance for unequal short-term losses/gains in favor of long-term mutual benefits" was added to capture this dimension. As a result, not only the defined risks/rewards sharing written in the contract was captured in the model, but also the unexpected and unequal risks/rewards during a partnership. The factor "tolerance for unequal short-term losses/gains in favor of long-term mutual benefits" was tested and accepted (using Cronbach's alphas test) in the survey chapter as an indicator of *Risk/reward sharing*.

From a practical perspective, the findings of this survey could help decision-makers in the forest industry in establishing new partnerships and revising their existing ones by providing more insight

into 1) the drivers for entering into partnerships and 2) the factors influencing partnership performance.

Although the establishment of new partnerships is emphasized in the studies on the partnership in forest products supply chain, there was a gap for a systematic approach for evaluating existing partnerships. Therefore, two multi-criteria decision support tools were developed for evaluating partnership performance and components quantitatively in Chapters 4 and 5, respectively.

In Chapter 4, a multi-criteria decision-making model was developed to evaluate the performance of an ongoing partnership. In order to develop the partnership performance evaluation model, first partnership's drivers and measures were drawn from the literature and were categorized based on partnership drivers. Then, the decisions makers for partnerships from each company were asked to select the relevant drivers and measures. Next, Interpretive Structural Modeling (ISM), Analytic Network Process (ANP) and Fuzzy Logic (FL) were used to evaluate interdependency, importance of, and uncertainty in these measures. Finally, a multi-criteria decision support model was developed to evaluate the performance of an ongoing partnership in different periods based on the measures associated with the drivers for entering into the partnership. Model outputs are: the importance of each performance measure, and a single number for overall partnership performance in each period, named as Partnership Performance Index (PPI).

The first developed model was applied to a case study, a partnership between a forest company and a sawmill. The results showed that the difference between the rankings from the proposed model, based on the importance values, and the rankings estimated by the managers were less than two. PPI was calculated for three years, 2011, 2012 and 2013, for the case study. In order to validate the PPIs' values, the rate of change in PPIs were compared with those of the other conventional methods (gain in market value and sales through partnership) during 2011-2013. As validated by

the managers, the changes in PPIs were comprehensive and better representative of the overall partnership performance, considering their joint projects and drivers over 2011-2013.

To reduce the high risk of failure (40% to 70%) for partnerships (Das and Teng, 2000), it is important to maintain and improve established partnerships by focusing on the activities that can be performed jointly by the partners which affect the performance of the partnership (components). There have been several multi-criteria models developed for selecting the best partner (e.g. Chen and Wu, 2010; Verdecho et al., 2012) or establishing the partnership (e.g. Simatupang and Sridharan, 2005; Bahinipati et al., 2009). However, there was a gap for multi-criteria decision support models to evaluate the components of an ongoing partnership over time. In Chapter 5, a comprehensive and systematic approach was used to evaluate the components of an ongoing partnership. The proposed multi-criteria model incorporated multiple indicators of the four major partnership's components in ongoing partnerships and their importance and interdependencies which were overlooked in similar models (Lambert et al., 1996; Simatupang and Sridharan, 2005). The four major components of partnerships were information sharing, joint decision-making, relationship-specific assets, and risk/reward sharing (Simatupang and Sridharan, 2005; Arshinder et al., 2008). Trust and commitment were not incorporated in the proposed model because of two reasons: 1) there was no consensus on the operational indicators of trust and commitment (Goodman and Dion, 2001; Stephen James Kelly, 2004; Seppänen et al., 2007; Laeequddin et al., 2010; McEvily and Tortoriello, 2011), and 2) trust and commitment were identified mostly as mediators between other four components and partnership performance rather than independent variables.

The modeling approach for evaluating the components of partnerships had five steps and had to be performed jointly by the partners. These steps included: 1) define the partnership components and their indicators, 2) determine the interdependencies between partnership components and their

indicators, 3) estimate the importance of the components and the indicators 4) quantify and normalize the indicators of partnership components in different periods, and 5) calculate the final importance of the components and their indicators and the overall Partnership Component Index (PCI). In the proposed model, the number of pairwise comparisons needed to estimate the weights of the components and their indicators were significantly reduced using two different approaches. First, Incomplete Pairwise Comparison was used in pairwise comparison matrices. Second, direct quantitative values for evaluating partnership were used against the indicators in each period rather than pairwise companions. As a result, there were fewer pairwise comparisons in this thesis compared to similar studies done by Verdecho et al. (2012) and Chen & Wu (2010).

The second proposed model was applied to the same case study, the partnership between the forest company and the sawmill. In this case study, the results showed that the "Percentage of sharing external risks" and "Shared land and equipment assets" were the most important indicators of the partnership components. In addition, the component indicators were categorized into three clusters in terms of their importance (high, medium or low). The results showed that 76% of categorization were the same for the model results and those by the managers.

From a methodological perspective, both proposed multi-criteria models had major differences compared to models developed for partnership evaluation (e.g. Lefaix-Durand et al., 2009; Simatupang and Sridharan, 2005; Chen and Wu, 2010; Verdecho et al., 2012). First, the proposed models incorporate partnership drivers and components and their importance in the process of estimating the importance of the performance measures and the components indicators. Second, in the proposed models the performance and components of a partnerships were evaluated in different time periods, while this was done before. Third, direct quantitative values were used in the proposed models instead of pairwise comparisons or rating scales.

From a practical perspective, the managers in the case study found that the rankings, PPIs and PCIs values and the process that led to a complete discussion of all the important components and indicators were beneficial. This modeling approach helped them clarify and communicate partnership drivers and their measures, and components and their indicators.

6.2 Limitations

In the survey in Chapter 3, the results cannot be generalized to the forest industry in other provinces or other industries due to the limited sample size. The non-response bias in this study was investigated by comparing the means of the different variables between early and late respondents groups using t tests (Armstrong and Overton, 1977). The late wave of survey responses was considered to be similar to those of non-respondents. Although, the test results suggested that non-response bias might not be a problem in this study, due to limited sample and the assumption of the similarity between the late responses and non-responses, it is remains necessary to consider and test different potential underlying factors for non-response effects. Another limitation of this survey is that the focus in this study was on companies with successful partnerships. Therefore, there were fewer companies in the sample.

In Chapters 4 and 5, the major limitations were related to the limited available data for testing the proposed models in the case study and the external validity of the specific type of supplier-manufacturer partnership. There are two major limitations with data availability. First, only three years were considered in the analysis. Therefore, it was not possible to statistically investigate the relationship between PPIs and PCIs. Second, even in those three years, not all the measures were recorded; as such, some data were estimated by the managers. In terms of the external validity of the case study, the investigated supplier-manufacturer partnership in this study might not be a typical type of supplier-manufacturer partnership in the forest industry, however the focus of this

study was on the proposed models rather than the type and mechanism of the supplier-manufacturer partnerships.

6.3 Future research

Regarding the survey of companies in the forest industry, future survey studies can investigate companies without partnerships and their reasons for not entering into a partnership, and companies with unsuccessful partnerships and the factors that contributed to their failures. Therefore, other companies not only can consider the factors influencing partnership performance positively (contributing to partnership success), but also can avoid or eliminate the factors causing partnership failure. In addition, similar studies can be done in other provinces in order to capture the geographical differences in partnerships practices.

For the model developed for partnership performance evaluation, the impact of external factors, such as market changes, can be further investigated. For example, if a change in a company's performance is due to macroeconomic effects in their respective market, it should not be reflected on partnership performance. Therefore, if the data for the change in the overall market is available, the modelers can deduct the overall market growth from company's sales growth over a specific period of time in order to exclude it from the partnership change. In the proposed model, incorporating the estimated *Market share* measure along with *Sales* would relatively balance out the change from overall market size. Although the case study was in the forest industry, the proposed models for partnership performance and components evaluation can be applied to other industries and for larger cases with more than two decision-makers to investigate model validity and reliability. Future studies can also apply the same modeling approach for more time periods to determine the pattern for change and to investigate the correlation between Partnership Performance Index (PPI) and Partnership Component Index (PCI). In the proposed multi-criteria

decision support models, the weights were assumed to be constant, varying weights or thresholds can be investigated further. The weights of the measures and indicators could vary in different time periods or for different values of variables. For example, the decrease in information sharing as about the inventory level when it is below a specific threshold could have more negative impact on the overall partnership components. If there were more data points available for the indicators, statistical tools such as Structural Equation Modeling could be used to find the interdependencies instead of the expert based methods. A smaller time interval or a longer period of data collection could also provide more data points.

Bibliography

Almenberg, J., Brooke, J.H., Clayton, P., Curtis, H.D., Dixon, T., Dreber, A., Fisher, J.C., Hall, N., Hauert, C., Hauser, M.D., Jackson, T.P., Dominic, J., Kosslyn, S.M., Lee, M., Lohmann, F., Porter, J., Pruss, A., Rota, M., Schloss, J.P., 2013. Evolution, Games, and God: The Principle of Cooperation. Harvard University Press, Cambridge, Massachusetts.

Ambus, L., Davis-Case, D., Mitchell, D., Tyler, S., 2007. Strength in diversity: Market opportunities and benefits from small forest tenures. BC J. Ecosyst. Manag. 8, 88–99.

Armstrong, J.S., Overton, T.S., 1977. Estimating Nonresponse Bias in Mail Surveys. J. Mark. Res. JMR 14, 396–402.

Arshinder, A., Kanda, A., Deshmukh, S.G., 2008. Supply chain coordination: Perspectives, empirical studies and research directions. Int. J. Prod. Econ. 115, 316–335.

Audy, J.-F., D'Amours, S., 2008. Impact of Benefit Sharing Among Companies in the Implantation of a Collaborative Transportation System - An Application in the Furniture Industry. Presented at the IFIP International Federation for Information Processing, Boston.

Audy, J.F., D'Amours, S., Rönnqvist, M., 2011. An empirical study on coalition formation and cost/savings allocation. Int. J. Prod. Econ. 136, 13–27.

Audy, J.-F., D'Amours, S., Rönnqvist, M., 2007. Business Models For Collaborative Planning In Transportation: An Application To Wood Products, in: Camarinha-Matos, L., Afsarmanesh, H., Novais, P., Analide, C. (Eds.), Establishing The Foundation Of Collaborative Networks, IFIP Advances in Information and Communication Technology. Springer Boston, pp. 667–676.

Audy, J.F., Lehoux, N., D'Amours, S., Rönnqvist, M., 2010. A framework for an efficient implementation of logistics collaborations. Int. Trans. Oper. Res. 19, 633–657.

Bahinipati, B.K., Kanda, A., Deshmukh, S.G., 2009. Horizontal collaboration in semiconductor manufacturing industry supply chain: An evaluation of collaboration intensity index. Comput. Ind. Eng. 57, 880–895.

Barney, J., 1991. Firm resources and sustained competitive advantage. J. Manag. 17, 99–120.

BarNir, A., Smith, K.A., 2002. Interfirm alliances in the small business: The role of social networks. J. Small Bus. Manag. 40, 219–232.

Baron, R.M., Kenny, D.A., 1986. The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. J. Pers. Soc. Psychol. 51, 1173.

Bayazit, O., 2006. Use of analytic network process in vendor selection decisions. Benchmarking Int. J. 13, 566–579.

Beach, R., Webster, M., Campbell, K.M., 2005. An evaluation of partnership development in the construction industry. Int. J. Proj. Manag. 23, 611–621.

Belton, V., Gear, T., 1983. On a short-coming of Saaty's method of analytic hierarchies. Omega 11, 228–230.

Bharadwaj, A.S., 2000. A Resource-Based Perspective on Information Technology Capability and Firm Performance: An Empirical Investigation. MIS Q. 24, 169–196.

Bitektine, A., 2011. Toward a Theory of Social Judgments of Organizations: The Case of Legitimacy, Reputation, and Status. Acad. Manage. Rev. 36, 151–179.

Bolloju, N., 2001. Aggregation of analytic hierarchy process models based on similarities in decision makers' preferences. Eur. J. Oper. Res. 128, 499–508.

Bourland, K.E., Powell, S.G., Pyke, D.F., 1996. Exploiting timely demand information to reduce inventories. Eur. J. Oper. Res. 92, 239–253.

Brinkerhoff, J., 2002. Assessing and improving partnership relationships and outcomes: a proposed framework. Eval. Program Plann. 25, 215–231.

Bruno, G., Esposito, E., Genovese, A., Passaro, R., 2012. AHP-based approaches for supplier evaluation: Problems and perspectives. J. Purch. Supply Manag. 18, 159–172.

Bull, G., Williams, J., 2006. The BC Forest Products Sector in a Globally Competitive Market: Developing a Strategic Response. BC Forum For. Econ. Policy.

Burkert, M., Ivens, B.S., Shan, J., 2012. Governance mechanisms in domestic and international buyer–supplier relationships: An empirical study. Ind. Mark. Manag. 41, 544–556.

Cachon, G.P., Lariviere, M.A., 2005. Supply chain coordination with revenue-sharing contracts: strengths and limitations. Manag. Sci. 51, 30–44.

Caniëls, M.C., Gelderman, C.J., 2007. Power and interdependence in buyer supplier relationships: A purchasing portfolio approach. Ind. Mark. Manag. 36, 219–229.

Carter, C.R., Kaufmann, L., Michel, A., 2007. Behavioral supply management: a taxonomy of judgment and decision-making biases. Int. J. Phys. Distrib. Logist. Manag. 37, 631–669.

Chai, J., Liu, J.N.K., Ngai, E.W.T., 2013. Application of decision-making techniques in supplier selection: A systematic review of literature. Expert Syst. Appl. 40, 3872–3885.

Chambost, V., McNutt, J., Stuart, P., 2009. Partnerships for successful enterprise transformation of forest industry companies implementing the forest biorefinery. Pulp Pap. Can. 110, 19–24.

Chang, B., Chang, C.-W., Wu, C.-H., 2011. Fuzzy DEMATEL method for developing supplier selection criteria. Expert Syst. Appl. 38, 1850–1858.

Chang, S.-H., Wang, K.-Y., Chih, W.-H., Tsai, W.-H., 2012. Building customer commitment in business-to-business markets. Ind. Mark. Manag. 41, 940–950.

Chen, C.-T., Lin, C.-T., Huang, S.-F., 2006. A fuzzy approach for supplier evaluation and selection in supply chain management. Int. J. Prod. Econ. 102, 289–301.

Chen, J.V., Yen, D.C., Rajkumar, T.M., Tomochko, N.A., 2011. The antecedent factors on trust and commitment in supply chain relationships. Comput. Stand. Interfaces 33, 262–270.

Chen, S., Wu, W., 2010. A systematic procedure to evaluate an automobile manufacturer distributor partnership. Eur. J. Oper. Res. 205, 687–698.

Cohen, D.H., Kozak, R.A., 2002. Research and technology: market-driven innovation in the twenty-first century. For. Chron. 78, 108–111.

Combs, J.G., Ketchen, D.J., 1999. Explaining interfirm cooperation and performance: toward a reconciliation of predictions from the resource-based view and organizational economics. Strateg. Manag. J. 20, 867–888.

Cruijssen, F., Dullaert, W., Fleuren, H., 2007. Horizontal cooperation in transport and logistics: a literature review. Transp. J. 46, 22–39.

D'Amours, S., Rönnqvist, M., 2010. Issues in Collaborative Logistics, in: Bjørndal, E., Bjørndal, M., Pardalos, P.M., Rönnqvist, M., Pardalos, P.M. (Eds.), Energy, Natural Resources and Environmental Economics, Energy Systems. Springer Berlin Heidelberg, pp. 395–409.

Dasmohapatra, S., Gonzalez, R.W., 2010. Hardwood Lumber Buyer Purchase Attributes and Relationships with Suppliers. For. Prod. J. 60, 266.

Das, T.K., Teng, B.S., 2000. Instabilities of strategic alliances: An internal tensions perspective. Organ. Sci. 11, 77–101.

Daugherty, P.J., 2011. Review of logistics and supply chain relationship literature and suggested research agenda. Int. J. Phys. Distrib. Logist. Manag. 41, 16–31.

Dawood, H., 2011. Theories of interval arithmetic: mathematical foundations and applications. Hend Dawood and LAP LAMBERT Academic Publishing.

De Boer, L., Labro, E., Morlacchi, P., 2001. A review of methods supporting supplier selection. Eur. J. Purch. Supply Manag. 7, 75–89.

DeLong, D., Kozak, R., Cohen, D., 2007. Overview of the Canadian value-added wood products sector and the competitive factors that contribute to its success. Can. J. For. Res. 37, 2211–2226.

Dyer, J.H., 1996. Specialized supplier networks as a source of competitive advantage: Evidence from the auto industry. Strateg. Manag. J. 17, 271–291.

Edgington, D., 2004. British Columbia's Coastal Forests, Hemlock Timber and the Japanese Housing Market. Can. J. Reg. Sci. 26, 415–446.

Eggert, A., Ulaga, W., Schultz, F., 2006. Value creation in the relationship life cycle: A quasi-longitudinal analysis. Ind. Mark. Manag. 35, 20–27.

Eisenhardt, K.M., Schoonhoven, C.B., 1996. Resource-based view of strategic alliance formation: Strategic and social effects in entrepreneurial firms. Organ. Sci. 7, 136–150.

Ellram, L.M., 1995. Partnering pitfalls and success factors. J. Supply Chain Manag. 31, 35–44.

Escobar, M.T., Moreno-jiménez, J.M., 2007. Aggregation of individual preference structures in AHP-group decision making. Group Decis. Negot. 16, 287–301.

Fischer, C., Hartmann, M., 2010. Agri-Food Chain Relationships. CABI.

Fontenot, R.J., Wilson, E.J., 1997. Relational exchange: a review of selected models for a prediction matrix of relationship activities. J. Bus. Res. 39, 5–12.

Forman, E.H., Selly, M.A., 2003. Decision by objectives. J.-Oper. Res. Soc. 54, 1108–1108.

FPAC, 2015a. Industry Overview. Forest Products Association of Canada, Canada.

FPAC, 2015b. Industry by numbers. The Forest Products Association of Canada (FPAC), Canada.

FPAC, 2011a. The Way Forward: Biopathways Phase II. Forest Products Association of Canada, Canada.

FPAC, 2011b. The New Face of the Canadian Forest Industry - The Emerging Bio-Revolution. The Forest Products Association of Canada (FPAC), Canada.

Frisk, M., Göthe-Lundgren, M., Jörnsten, K., Rönnqvist, M., 2010. Cost allocation in collaborative forest transportation. Eur. J. Oper. Res. 205, 448–458.

Gencer, C., Gurpinar, D., 2007. Analytic network process in supplier selection: A case study in an electronic firm. Appl. Math. Model. 31, 2475–2486.

George, J.K., Yuan, B., 2001. Fuzzy sets and fuzzy logic: theory and applications. N. J.

Geyskens, Steenkamp, J. benedicte M., Kumar, N., 2006. Make, buy, or ally: a transaction cost theory meta-analysis. Acad. Manag. J. Arch. 49, 519–543.

Glaister, K.W., Buckley, P.J., 1998. Measures of performance in UK international alliances. Organ. Stud. 19, 89–118.

Goodman, L.E., Dion, P.A., 2001. The Determinants of Commitment in the Distributor–Manufacturer Relationship. Ind. Mark. Manag. 30, 287–300.

Gordon Stewart, 1997. Supply-chain operations reference model (SCOR): the first cross-industry framework for integrated supply-chain management. Logist. Inf. Manag. 10, 62–67.

Greenwood, P.E., Nikulin, M.S., 1996. A guide to chi-squared testing. John Wiley & Sons.

Gunasekaran, A., Kobu, B., 2007. Performance measures and metrics in logistics and supply chain management: a review of recent literature (1995–2004) for research and applications. Int. J. Prod. Res. 45, 2819–2840.

Haladyna, T.M., 2004. Developing and Validating Multiple-choice Test Items. Routledge.

Handfield, R., Bechtel, C., 2002. The role of trust and relationship structure in improving supply chain responsiveness. Ind. Mark. Manag. 31, 367–382.

Hansda, R., 2009. The outlook for non-wood forest products in Asia and the Pacific. Working Paper No. APFSOS II/WP/2009/18. Asia-Pacific Forestry Sector Outlook Study II Working Paper Series. FAO Bangkok.

Harker, P.T., 1987. Incomplete pairwise comparisons in the analytic hierarchy process. Math. Model. 9, 837–848.

Harrigan, K.R., 1986. Strategic alliances and partner asymmetries. Graduate School of Business, Columbia University.

Heide, J.B., Stump, R.L., 1995. Performance implications of buyer-supplier relationships in industrial markets: A transaction cost explanation. J. Bus. Res. 32, 57–66.

Hoffmann, W.H., Schlosser, R., 2001. Success Factors of Strategic Alliances in Small and Medium-sized Enterprises–An Empirical Survey. Long Range Plann. 34, 357–381.

Holmberg, S.R., Cummings, J.L., 2009. Building Successful Strategic Alliances: Strategic Process and Analytical Tool for Selecting Partner Industries and Firms. Long Range Plann. 42, 164–193.

Ho, W., Xu, X., Dey, P.K., 2010. Multi-criteria decision making approaches for supplier evaluation and selection: A literature review. Eur. J. Oper. Res. 202, 16–24.

Hua, H., Cong, P., 2011. Information Sharing of Partnership in Supply Chain and Enhancement of Core Competitiveness of Enterprises. Commun. Syst. Inf. Technol. 100, 875–883.

Huang, G.Q., Lau, J.S.K., Mak, K.L., 2003. The impacts of sharing production information on supply chain dynamics: A review of the literature. Int. J. Prod. Res. 41, 1483–1517.

Hughes, J., Weiss, J., 2007. Simple rules for making alliances work. Harv. Bus. Rev. 85, 122.

Jacobides, M.G., Billinger, S., 2006. Designing the boundaries of the firm: From "make, buy, or ally" to the dynamic benefits of vertical architecture. Organ. Sci. 17, 249–261.

Janssen, M., Chambost, V., Stuart, P.R., 2008. Successful partnerships for the forest biorefinery. Ind. Biotechnol. 4, 352–362.

Johnston, D.A., McCutcheon, D.M., Stuart, F.I., Kerwood, H., 2004. Effects of supplier trust on performance of cooperative supplier relationships. J. Oper. Manag. 22, 23–38.

Joint Report, 2012a. Manufacturing - BC Stats. BCStats, British Columbia.

Joint Report, 2012b. Pulp and paper product manufacturing industry. Canada's national statistical agency.

Jolly, A., 2003. Managing Business Risk. Kogan Page Publishers.

Kahraman, C., Cebeci, U., Ulukan, Z., 2003. Multi-criteria supplier selection using fuzzy AHP. Logist. Inf. Manag. 16, 382–394.

Kannan, G., Pokharel, S., Sasi Kumar, P., 2009. A hybrid approach using ISM and fuzzy TOPSIS for the selection of reverse logistics provider. Resour. Conserv. Recycl. 54, 28–36.

Kaplan, R.S., Norton, D.P., 1996. The balanced scorecard: translating strategy into action. Harvard Business Press.

Karuranga, É., Frayret, J.M., D'Amours, S., 2008. Measurement and Determinants of Supply Chain Collaboration. CIRRELT, Universite de Montreal.

Katok, E., Pavlov, V., 2013. Fairness in supply chain contracts: A laboratory study. J. Oper. Manag. 31, 129–137.

Kemppainen, K., Vepsäläinen, A.P.J., 2003. Trends in industrial supply chains and networks. Int. J. Phys. Distrib. Logist. Manag. 33, 701–719.

Khan, S., Faisal, M.N., 2008. An analytic network process model for municipal solid waste disposal options. Waste Manag. 28, 1500–1508.

Kim, D.Y., Kumar, V., Kumar, U., 2010. Performance assessment framework for supply chain partnership. Supply Chain Manag. Int. J. 15, 187–195.

Kim, K., Park, J.-H., 2002. The determinants of value creation for partner firms in the global alliance context. MIR Manag. Int. Rev. 42, 361–384.

Kozak, R.A., Cohen, D.H., 1997. Distributor-supplier partnering relationships: A case in trust. J. Bus. Res. 39, 33–38.

Kozak, R., Maness, T.C., 2005. Towards a value focused forest sector in British Columbia. BC FORUM Value Focus. For. Sect. Issues Brief IB05-01, 1–8.

KPMG International, 2012. Managing growth while navigating uncharted routes. KPMG International.

Kwon, I.-W.G., Suh, T., 2005. Trust, commitment and relationships in supply chain management: a path analysis. Supply Chain Manag. Int. J. 10, 26–33.

Kwon, I.W.G., Suh, T., 2004. Factors affecting the level of trust and commitment in supply chain relationships. J. Supply Chain Manag. 40, 4–14.

Laeequddin, M., Sahay, B.S., Sahay, V., Waheed, K.A., 2010. Measuring trust in supply chain partners' relationships. Meas. Bus. Excell. 14, 53–69.

Lambert, D., Emmelhainz, M., Gardner, 1996. Developing and implementing supply chain partnerships. Int. J. Logist. Manag. 7, 1–18.

Lawson, D., 1997. GPI distributors: Field notes on a partnering relationship for sustainable business. J. Bus. Res. 39, 53–58.

Lefaix-Durand, A., Kozak, R., 2010. Comparing customer and supplier perceptions of value offerings: An exploratory assessment. J. Bus. Mark. Manag. 4, 129–150.

Lefaix-Durand, A., Kozak, R., 2009. Integrating transactional and relational exchange into the study of Exchange Orientation in customer relationships. J. Mark. Manag. 25, 1003–1025.

Lefaix-Durand, A., Kozak, R., Beauregard, R., Poulin, D., 2009. Extending relationship value: observations from a case study of the Canadian structural wood products industry. J. Bus. Ind. Mark. 24, 389–407.

Lehoux, N., D'Amours, S., Langevin, A., 2010. A win-win collaboration approach for a two-echelon supply chain: a case study in the pulp and paper industry. Eur. J. Ind. Eng. 4, 493–514.

Lehoux, N., D'Amours, S., Langevin, A., Centre interuniversitaire de recherche sur les réseaux d'entreprise, la logistique et le transport, 2007. Collaboration and decision models for a two-echelon supply chain: a case study in the pulp and paper industry. CIRRELT.

Lewin, J.E., Johnston, W.J., 1997. Relationship marketing theory in practice: a case study. J. Bus. Res. 39, 23–31.

Likert, R., 1932. A technique for the measurement of attitudes. Arch. Psychol.

Liu, C., 2004. Multi-Item Measures. Lewis-Beck MS Bryman Liao TF's Sage Encycl. Soc. Sci. Res. Methods Thousand Oaks Calif Sage.

Lucintel, 2012. Global Paper Industry 2012-2017: Trends, Profits and Forecast Analysis. Lucintel.

Luo, Y., Chen, M., 1995. Financial performance comparison between international joint ventures and wholly foreign-owned enterprises in China. Int. Exec. 37, 599–613.

Maheshwari, B., Kumar, V., Kumar, U., 2006. Optimizing success in supply chain partnerships. J. Enterp. Inf. Manag. 19, 277–291.

Maloni, M.J., Benton, W., 1997. Supply chain partnerships: opportunities for operations research. Eur. J. Oper. Res. 101, 419–429.

Markus, L., 2004. Make, Buy or Share. Wirtschaftsinformatik 46, 204–212.

Mayers, J., Vermeulen, S., 2002. Company-community forestry partnerships: From raw deals to mutual gains. Int. Inst. Environ. Dev. Lond.

McEvily, B., Tortoriello, M., 2011. Measuring trust in organisational research: Review and recommendations. J. Trust Res. 1, 23–63.

Min, H., Zhou, G., 2002. Supply chain modeling: past, present and future. Comput. Ind. Eng. 43, 231–249.

Mohr, J., Spekman, R., 1994. Characteristics of partnership success: partnership attributes, communication behavior, and conflict resolution techniques. Strateg. Manag. J. 15, 135–152.

Monczka, R.M., Petersen, K.J., Handfield, R.B., Ragatz, G.L., 1998. Success Factors in Strategic Supplier Alliances: The Buying Company Perspective. Decis. Sci. 29, 553–577.

Moorman, C., Deshpande, R., Zaltman, G., 1993. Factors affecting trust in market research relationships. J. Mark. 81–101.

Morgan, R.M., Hunt, S.D., 1994. The commitment-trust theory of relationship marketing. J. Mark. 20–38.

Moyaux, T., Chaib-draa, B., D'Amours, S., 2004. The impact of information sharing on the efficiency of an ordering approach in reducing the bullwhip effect. IEEE Trans Syst. Man Cybern. 7, 1–15.

Mudambi, S.M., Tallman, S., 2010. Make, buy or ally? Theoretical perspectives on knowledge process outsourcing through alliances. J. Manag. Stud. 47, 1434–1456.

Narayanan, V.G., Raman, A., 2004. Aligning incentives in supply chains. Harv. Bus. Rev. 82, 94–102.

Neumann, S., Segev, E., 1979. A case study of user evaluation of information characteristics for systems improvement. Inf. Manage. 2, 271–278.

Nunnally, J.C., 1978. Psychometric theory. McGraw-Hill.

Paun, D.A., 1997. A study of "best" versus "average" buyer-seller relationships. J. Bus. Res. 39, 13–21.

Perçin, E., 2008. Use of fuzzy AHP for evaluating the benefits of information-sharing decisions in a supply chain. J. Enterp. Inf. Manag. 21, 263–284.

Peteraf, M.A., 1993. The cornerstones of competitive advantage: a resource-based view. Strateg. Manag. J. 14, 179–191.

Poppo, L., Zenger, T., 2002. Do formal contracts and relational governance function as substitutes or complements? Strateg. Manag. J. 23, 707–725.

Primo, M.A.M., Amundson, S.D., 2002. An exploratory study of the effects of supplier relationships on new product development outcomes. J. Oper. Manag. 20, 33–52.

Ramanathan, 2013. Aligning supply chain collaboration using Analytic Hierarchy Process. Omega 41, 431–440.

Ramanathan, R., Ganesh, L., 1994. Group preference aggregation methods employed in AHP: An evaluation and an intrinsic process for deriving members' weightages. Eur. J. Oper. Res. 79, 249–265.

Reddy, A.M., Rajendran, C., 2005. A simulation study of dynamic order-up-to policies in a supply chain with non-stationary customer demand and information sharing. Int. J. Adv. Manuf. Technol. 25, 1029–1045.

Rezaei, J., Ortt, R., Trott, P., 2015. How SMEs can benefit from supply chain partnerships. Int. J. Prod. Res. 53, 1527–1543.

Rinehart, L.M., Eckert, J.A., Handfield, R.B., Page Jr., T.J., Atkin, T., 2004. An Assessment of Supplier — Customer Relationships. J. Bus. Logist. 25, 25–62.

Ryu, I., So, S.H., Koo, C., 2009. The role of partnership in supply chain performance. Ind. Manag. Data Syst. 109, 496–514.

Saaty, T., 1996. The analytic network process: decision making with dependence and feedback. RWS Publications, Pittsburgh, PA.

Saaty, T.L., 2008. Decision making with the analytic hierarchy process. Int. J. Serv. Sci. 1, 83–98.

Saaty, T.L., 2005. Theory and Applications of analytic network process. RWS publications Pittsburgh, PA.

Saaty, T.L., 1980. The analytical hierarchy process. McGraw-Hill, New York.

Saaty, T.L., Tran, L.T., 2007. On the invalidity of fuzzifying numerical judgments in the Analytic Hierarchy Process. Math. Comput. Model., Decision Making with the Analytic Hierarchy Process and the Analytic Network Process 46, 962–975.

Sathre, R., Gustavsson, L., 2009. Process-based analysis of added value in forest product industries. For. Policy Econ. 11, 65–75.

Saxton, T., 1997. The Effects of Partner and Relationship Characteristics on Alliance Outcomes. Acad. Manage. J. 40, 443–461.

Seppänen, R., Blomqvist, K., Sundqvist, S., 2007. Measuring inter-organizational trust—a critical review of the empirical research in 1990–2003. Ind. Mark. Manag. 36, 249–265.

Shen, Y., Hoerl, A., McConnell, W., 1992. An incomplete design in the analytic hierarchy process. Math. Comput. Model. 16, 121–129.

Shepherd, C., Günter, H., 2011. Measuring supply chain performance: current research and future directions, in: Behavioral Operations in Planning and Scheduling. Springer, pp. 105–121.

Sheth, J.N., Parvatiyar, A., 1992. Towards a theory of business alliance formation. Scand. Int. Bus. Rev. 1, 71–87.

Simatupang, T.M., Sridharan, R., 2005. The collaboration index: a measure for supply chain collaboration. Int. J. Phys. Distrib. Logist. Manag. 35, 44–62.

Simatupang, T.M., Sridharan, R., 2004. A benchmarking scheme for supply chain collaboration. Benchmarking Int. J. 11, 9–30.

Simpson, J.T., Wren, B.M., 1997. Buyer-seller relationships in the wood products industry. J. Bus. Res. 39, 45–51.

Smith, P.M., Ross, E.S., Smith, T., 1997. A case study of distributor-supplier business relationships. J. Bus. Res. 39, 39–44.

Sodhi, M.M.S., Son, B.G., 2009. Supply-chain partnership performance. Transp. Res. Part E Logist. Transp. Rev. 45, 937–945.

Spekman, R.E., Jr, J.W.K., Myhr, N., 1998. An empirical investigation into supply chain management: A perspective on partnerships. Int. J. Phys. Distrib. Logist. Manag. 28, 630–650.

Stennes, B.K., Wilson, B., 2008. Secondary Manufacturing of Solid Wood Products in British Columbia, 2006: Structure, Economic Contribution and Changes Since 1990. Pacific Forestry Centre.

Stephen James Kelly, 2004. Measuring attitudinal commitment in business-to-business channels. Mark. Intell. Plan. 22, 636–651.

Street, C.T., Cameron, A.-F., 2007. External Relationships and the Small Business: A Review of Small Business Alliance and Network Research. J. Small Bus. Manag. 45, 239–266.

Tabachnick, B.G., Fidell, L.S., Osterlind, S.J., 2001. Using multivariate statistics.

Thakkar, J., Deshmukh, S., Gupta, A., Shankar, R., 2006. Development of a balanced scorecard: an integrated approach of interpretive structural modeling (ISM) and analytic network process (ANP). Int. J. Product. Perform. Manag. 56, 25–59.

Tzeng, G.-H., Huang, J.-J., 2011. Multiple attribute decision making: methods and applications. CRC Press.

Van Den Honert, R., Lootsma, F., 1997. Group preference aggregation in the multiplicative AHP The model of the group decision process and Pareto optimality. Eur. J. Oper. Res. 96, 363–370.

Van Leekwijck, W., Kerre, E.E., 1999. Defuzzification: criteria and classification. Fuzzy Sets Syst. 108, 159–178.

Verdecho, M.-J., Alfaro-Saiz, J.-J., Rodriguez-Rodriguez, R., Ortiz-Bas, A., 2012. A multi-criteria approach for managing inter-enterprise collaborative relationships. Omega 40, 249–263.

Vereecke, A., Muylle, S., 2006. Performance improvement through supply chain collaboration in Europe. Int. J. Oper. Prod. Manag. 26, 1176–1198.

Vlosky, R.P., Wilson, E.J., Cohen, D.H., Fontenot, R., Johnston, W.J., Kozak, R.A., Lawson, D., Lewin, J.E., Paun, D.A., Ross, E.S., Simpson, J.T., Smith, P.M., Smith, T., Wren, B.M., 1998. Partnerships versus typical relationships between wood products distributors and their manufacturer suppliers. For. Prod. J. 48, 27–35.

Wang, J., Shu, Y.F., 2005. Fuzzy decision modeling for supply chain management. Fuzzy Sets Syst. 150, 107–127.

Wang, Y.-M., Elhag, T.M., 2006. An approach to avoiding rank reversal in AHP. Decis. Support Syst. 42, 1474–1480.

Warfield, J.N., 1982. Interpretive structural modeling. Group Plan. Probl.-Solving Methods Eng. N. Y. Wiley 155–201.

Warren, H.S., Jr., 1975. A Modification of Warshall's Algorithm for the Transitive Closure of Binary Relations. Commun ACM 18, 218–220.

Water, H., Peet, H., 2006. A decision support model based on the Analytic Hierarchy Process for the Make or Buy decision in manufacturing. J. Purch. Supply Manag. 12, 258–271.

Webster, F.E., 1992. The Changing Role of Marketing in the Corporation. J. Mark. 56, 1–17.

Weiss, E.N., Rao, V.R., 1987. AHP design issues for large-scale systems. Decis. Sci. 18, 43–57.

Wernerfelt, B., 1984. A resource-based view of the firm. Strateg. Manag. J. 5, 171–180.

Whipple, J.M., Frankel, R., 2000. Strategic Alliance Success Factors. J. Supply Chain Manag. 36, 21–28.

Wilson, D., 1995. An integrated model of buyer-seller relationships. J. Acad. Mark. Sci. 23, 335–345.

Wilson, D.T., Vlosky, R.P., 1998. Interorganizational information system technology and buyer-seller relationships. J. Bus. Ind. Mark. 13, 215–234.

Wilson, E.J., Vlosky, R.P., 1997. Partnering relationship activities: building theory from case study research. J. Bus. Res. 39, 59–70.

Wu, C., Barnes, D., 2011. A literature review of decision-making models and approaches for partner selection in agile supply chains. J. Purch. Supply Manag. 17, 256–274.

Wu, W.-Y., Chiag, C.-Y., Wu, Y.-J., Tu, H.-J., 2004. The influencing factors of commitment and business integration on supply chain management. Ind. Manag. Data Syst. 104, 322–333.

Yoshino, M.Y., Rangan, U.S., 1995. Strategic Alliances: An Entrepreneurial Approach to Globalization. Harvard Business Press.

Yu, M.M., Ting, S.C., Chen, M.C., 2010. Evaluating the cross-efficiency of information sharing in supply chains. Expert Syst. Appl. 37, 2891–2897.

Yurdakul, M., 2003. Measuring long-term performance of a manufacturing firm using the analytic network process (ANP) approach. Int. J. Prod. Res. 41, 2501–2529.

Appendix

Appendix A : Questionnaire

1- Please check the appropriate boxes in each row to describe your company:

Sector ○ Sawmills & preservation ○ Paperboard container ○ Coated & treated paper ○ Veneer, plywood & engineered products ○ Sanitary paper product ○ Pulp mills ○ Paper and newsprint ○ Furniture ○ Window, door and building products ○ Wood container and pallet ○ Paperboard ○ Stationery product ○ Cabinets ○ Mobile and prefabricated home ○ Logging

Region ○ Mainland/Southwest ○ Vancouver Island/Coast ○ Thompson-Okanagan ○ Other

Export (% of total income) ○ 0% ○ 1-9% ○ 10-29% ○ 30-49% ○ 50-70% ○ >70%

No. of full time employees ○ <10 ○ 10-49 ○ 50–99 ○ 100–199 ○ 200–500 ○ >500

Gross revenue in $Million ○ <1 ○ 1-4 ○ 5-24 ○ 25-49 ○ 50-75 ○ >75

Year of establishment ○ before 1970 ○ 1970-1980 ○ 1981-1990 ○ 1991-2000 ○ after 2001

Management ○ By owners ○ By non-owners

Do you belong to any Industry Associations? ○ Yes ○ No

2- Please answer the following questions regarding your existing and planned partnerships (within the next five years)?

2-1. From the list below, select all types of partners that you have and you plan to have in the next 5 years?

Existing partnership ○ Suppliers ○ Ultimate customers ○ Intermediate customers (e.g. distributors or mills) ○ Community-based partnership ○ Competitors ○ Research institutes (e.g. universities) ○ Service suppliers ○ Technology providers

Your plan ○ Suppliers ○ Ultimate customers ○ Intermediate Customers ○ Community-based partnership ○ Competitors ○ Research institutes ○ Service suppliers ○ Technology providers

2-2. From the list below select the main approach that you are using and/or you are planning to use for information sharing with your partners?

Existing partner ○ Face-to-face ○ Fax/phone ○ Email ○ Customized website ○ Enterprise Resource Planning software

Your plan ○ Face-to-face ○ Fax/phone ○ Email ○ Customized website ○ Enterprise Resource Planning software

2-3. Please indicate the importance of the following drivers (objectives) for your existing partnership and planned partnership on a scale of 1-5, where 1= "Not at all", 2= "Low", 3= "Average", 4="High" and 5= "Very high".

		1	2	3	4	5
– Developing new products and/or new technologies (e.g. new production technology)	Existing	○	○	○	○	○
	Your plan	○	○	○	○	○
– Investing in new projects (e.g. investing jointly for acquiring a new technology)	Existing	○	○	○	○	○
	Your plan	○	○	○	○	○
– Marketing (e.g. advertisement and promotion)	Existing	○	○	○	○	○
	Your plan	○	○	○	○	○
– Reducing costs (e.g. sharing resources in logistics, human resources and production)	Existing	○	○	○	○	○
	Your plan	○	○	○	○	○
– Improving customer service (e.g. delivery, quality)	Existing	○	○	○	○	○
	Your plan	○	○	○	○	○
– Diversifying product portfolio/reducing risk (e.g. producing new products)	Existing	○	○	○	○	○
	Your plan	○	○	○	○	○

– Please add your divers and their importance in the space below, if they are not listed above (separate them by existing and planned partnerships and rate their importance form 1-5):

3- Please answer the following questions regarding your most successful partnership (if you do not have any partnership, please answer only questions in section 3-5 about the important factors in your planned partnership)?

3-1. From the list below select the type of your most successful partnership?

○ Suppliers	○ Ultimate customers	○ Intermediate customers	○ Community-based partnership
○ Competitors	○ Research institutes	○ Service suppliers	○ Technology providers

3-2. From the list below select the length of your most successful partnership?

○ Less than a year ○ 1-3 year ○ 4-6 year ○ 7-10 year ○ More than 10 year

3-3. Where does your most successful business partner operate?

○ British Columbia ○ Other provinces ○ US ○ Europe ○ Asia ○ Latin America ○ Africa

3-4. To what extent has your most successful partnership achieved its objectives (drivers) approximately?

0-19%	20-39%	40-59%	60-79%	80-100%
○	○	○	○	○

3-5. To what extent is each of the following factors important in your partnership (on a scale of 1-5, where 1= "Not at all", 2= "Low", 3= "Average", 4="High" and 5= "Very high"?

Similarity in	1	2	3	4	5
– size in terms of market share in the respective sector	○	○	○	○	○
– reputation and brand image	○	○	○	○	○
– technological sophistication	○	○	○	○	○
Mutuality in	1	2	3	4	5
– having similar time horizon planned for the relationship	○	○	○	○	○
– expressing goals and sharing expectations	○	○	○	○	○
– willing to change and integrate systems by managers	○	○	○	○	○
Compatibility in	1	2	3	4	5
– strategic plans and business objectives	○	○	○	○	○
– organizational structure	○	○	○	○	○

3-5. To what extent does each of the following factors exist in your most successful partnership, (on a scale of 1-5, where 1= "Not at all", 2= "Low", 3= "Average", 4="High" and 5= "Very high"?

	1	2	3	4	5
Joint decision-making					
– regularly scheduled joint decision-making on partnering activities	○	○	○	○	○
– regular joint decision- making on long-term plans	○	○	○	○	○
Information sharing	1	2	3	4	5
– operational information regarding partnering activities	○	○	○	○	○
– strategic information regarding future plans and changes	○	○	○	○	○
Risks and rewards sharing	1	2	3	4	5
– defined risk and reward sharing contracts/agreements	○	○	○	○	○
– tolerance for short-term losses in favor of long-term benefits	○	○	○	○	○
Relationship-specific assets	1	2	3	4	5
– personnel exchange and joint training programs	○	○	○	○	○
– ICT solutions specifically for your partnership	○	○	○	○	○
– non-IT and non-human assets tailored to the partnership	○	○	○	○	○
Trust	1	2	3	4	5
– level of trust in your partnership	○	○	○	○	○
Commitment	1	2	3	4	5
– keeping the promises made	○	○	○	○	○

4. If you have any comments or would like to provide additional information about your existing or future partnerships, please add them here.