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Measurement and Determinants of Supply Chain Collaboration

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Abstract. Supply chain management and inter-firm collaboration is a growing field of study for the researcher and a hot topic for the supply chain manager. Despite this unanimous interest, the measurement of supply chain collaboration has received little attention to date. This paper proposes a reliable and valid measurement model of supply chain collaboration based on data from 321 companies from the Quebec forest products industry using structural equations modeling. In spite of the general low level of collaboration in this traditional industry, a first order measurement model followed by a second order confirmatory factor analysis suggest that collaboration in the forest products industry can be defined by four indicators shared by both customer and supplier sides and 2 indicators specific to each side.

Keywords. Collaboration, supply chain, structural equation model, forest products industry.

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1 Introduction

Supply chain management and inter-firm collaboration is a growing field of study for the researcher and a hot topic for the supply chain manager. The former sees an opportunity to develop new models and technology to support collaborative practices, while the latter sees an opportunity to reap the benefit of supply chain management. Despite this unanimous interest, the measurement of supply chain collaboration has received little attention to date (Sanders and Premus, 2005; Jap, 1999; Injazz and Paulraj, 2004). This paper seeks to fill this gap by providing a reliable and valid measurement model of collaboration intensity and its determinants.

The paper is organized as follows. Section 2 presents a review of the literature concerning the practices of supply chain collaboration and its measurement methods identified in previous studies. Next, the research questions addressed in this study are stated. The questionnaire development and the data collection procedures are described in the fourth section. Then, data analysis methodologies are presented in the fifth section. The sixth section presents the main results showing twelve reliable and valid indicators of the collaboration level. The last section discusses the implications for researchers and practitioners.

2 Literature review

Simatupang and Sridharan (2002) define supply chain collaboration as being "*two or more chain members working together to create a competitive advantage through sharing information, making joint decisions, and sharing benefits which result from greater profitability of satisfying end customer needs than acting alone*."

Supply chain collaboration is widely studied from different perspectives. This review of the literature first proposes an overview of various classification schemes of supply chain collaboration. Next, the literature dealing with the measure of supply chain collaboration levels is overviewed, followed by a review of the literature dealing with the study of the determinants of collaboration. Finally, the role of IT in collaboration is also introduced.

2.1 Classification schemes of collaboration

Traditionally, transaction-oriented relationships between organizations have led companies within supply chains to act as competitors trying to take advantage of each other to maximize one's own utility. In such a context, companies see themselves as buyers of goods and sellers of value-added goods. This adversarial business model promotes opportunistic behaviors as the profit made by others is seen as an opportunity to improve one's own benefits.

With the progressive adoption of modern supply chain practices (e.g., VMI, CPFR, early supplier involvement), several authors have proposed evolution models of B2B relationships, from purely transactional to collaborative. These relationships models are generally based on a three-level scale from short-term transactional exchanges to long-term relationship involving several dimensions of collaborative practice including collaborative product design and joint investment (Merli, 1991; Lapide, 2002). The development of such frameworks generally considers that B2B relationships evolve from transactional through various stages to collaboration, which leads to classification schemes of B2B relationships that provide qualitative measurement scales of supply chain collaboration levels.

Along this line, Poulin *et al*. (1994) propose a detailed classification of inter-organizational relationships on a continuum from the traditional supplier relationship to the creation of co-enterprises. The study of these relationships leads the authors to the identification of three generic classes from adversarial to collaborative relationships: supply relationships, outsourcing relationships, and co-production relationships.

Others classification schemes of collaboration have similarly been proposed in the literature. However, instead of identifying classes of practices, these schemes propose to classify the means used by companies to introduce collaboration within their organization. For instance, Simatupang and Sridharan (2002) identify six means of collaboration, which include the setup of joint objectives to better control demand variability; the integration of decision rules to improve response coordination to market signal; the use of appropriate measures of performance to align the partners' efforts; the creation of coherent decision domains to improve supply chain decisions; information sharing to improve decision making; and the use of an appropriate incentive system to improve supply chain decisions. Similarly, Frayret (2002) identifies six generic patterns of collaboration (see Table 1).

Table 1. Patterns of collaboration (Frayret (2002))

Type	Principle	Examples of practice
Outsourced local decision-making	Increase the level of responsibility of suppliers	Vendor-managed inventory, supplier quality program, early supplier involvement (component design)
Improved local decision-making	Enhance and align local decision-making	Information sharing, shared POS data, joint capacity management, joint inventory management
Decision objective alignment	Joint objective planning and objective alignment	Collaborative forecasting, collaborative promotion planning, early supplier involvement, category management
Pooled resource and capacity sharing	Resource pooling and sharing, and joint investment	Shared pallets, joint trailer, 3PL (mediated resource sharing), joint facility and R&D investment, shared prototyping facility
Process and IS integration	Business process and information system integration	JIT supplier (ex.: Toyota), CPFR standards adoption, B2B marketplace, E-business standards compliant
Supply chain process reengineering	Internal business process redesign and alignment	Joint cycle time reduction, supply chain event management, suppliers training and evaluation, process postponement, performance metrics

These patterns of collaboration include the outsourcing of decision rights; the coordination of supply chain decisions; the identification of common goals, which indirectly tends to coordinate supply chain decisions; the pooling of resources; the use of transactional integration framework and technologies; and the undertaking of a multi-company effort of supply chain reengineering.

Differently, some authors also propose to classify the opportunities of supply chain collaboration. For instance, Lapide (2002) identifies three areas of opportunities: between a manufacturer and its suppliers, between a manufacturer and its distribution channel members, and between the manufacturers and a logistic service provider. Frayret *et al*. (2003) present an activity-based synthesis of a wider range of opportunities by studying collaborative practices involving research and development, procurement, production, marketing and distribution and sales. These opportunities can also be classified according to the nature of the partner involved (Figure 1).

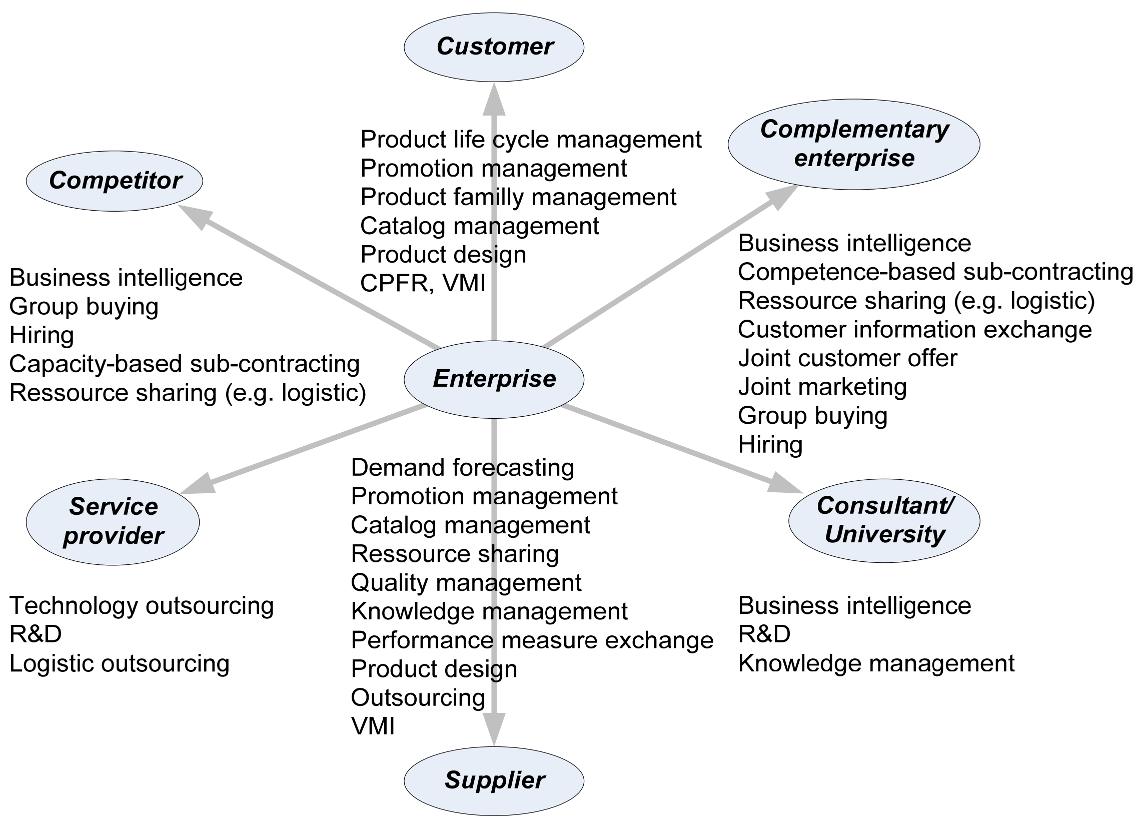

Figure 1: Collaboration Opportunities (adapted from Frayret *et al*. 2003)

2.2 Measures of supply chain collaboration level

Past and recent studies on collaboration have taken different paths in measuring collaboration levels. Certainly the first approach to assess the level of collaboration between supply chain partners is based on the evolution models of B2B relationships mentioned in the previous section. This type of approaches gives a qualitative assessment of the collaboration level of a relationship by identifying the closest class of collaboration level it belongs to.

Other authors have studied the impact of particular B2B collaborative practices on supply chain performance. By doing so, they propose empirical assessment methods of collaboration levels through five-point scales designed to evaluate the adoption level of a set of specific collaborative practices. For instance, Stank *et al.*, (2001) develop a measurement method that considers both internal and external collaborative practices. Similarly, Vereecke and Muylle (2006) consider in their method both relationships with key suppliers and customers.

Simatupang and Sridharan (2005) propose a similar approach, although more detailed, to measure a quantitative index of collaboration using a three-dimensional framework based on information sharing, decisions synchronization and incentive alignment. Each of these dimensions includes several items specifically developed for retailer-supplier collaborative practices. The evaluation of the level of adoption of each practice (using also five-point scales) contributes to measuring the level of information sharing, decisions synchronization and incentive alignment practices, and ultimately the collaboration index.

2.3 Collaboration: a multiple causes\multiple indicators construct?

Similarly, several paths have been explored in the literature to measure and study the determinants of collaboration. For instance, a strong stream of research based on characteristics of actors and type of collaboration is represented, among others, by Scott (1991), Wasserman and Faust (1997), and Fritsch and Lukas (2001). For these authors, operationalized characteristics include institutional background, resources, psychological and intellectual predispositions, and learning styles. Large firms are found to be more apt to collaborate than small ones, especially in research and development activities. In Kleinknecht and Van Reijnen (1992) and Fritsch and Lukas (2001), the effects of the type of partner and type of agreement are studied as well.

In Heide and John (1992), the authors study a slightly different context characterized by strong buyers facing small suppliers with the risk of an opportunistic behavior endangering the expected collaboration. They find that norms play a great role in leveraging obstacles. In contrast, the dynamic of strong suppliers with a myriad of small buyers was investigated by Berthon *et al*. (2003). Converse to Heide and John's findings, Berthon *et al*. (2003) empirically find that relational norms has no effect as governance mechanisms safeguarded against opportunistic behavior in the presence of transaction-specific assets. However, power dependence theory has been validated as the size of the buyer positively influenced buyer control.

According to Achrol (1997), collaborators in a network are also described by their density, their multiplicity, their reciprocity of ties, and their shared values. Network density has also been studied by Farrell and Klemper (2004) with an emphasis on "*instrumental intimacy*" in which firms feed each other through reciprocal influences in the design of new products and application of business strategies. Trust and commitment are antecedents and central characteristics of collaboration. The involvement of a supplier in the development of a new product can be rated in different levels. For instance, the highest level of collaboration occurs when there is an exchange of staff in the design, development and testing of new products and ideas (Handfiel *et al*. 1999; Wasti and Liker, 1997). In Riiter *et al*. (2002), the authors identify four main antecedents with strong impacts on a company's network competence: access to resources, network orientation of human resource management, integration of intra-organizational communication, and openness of corporate culture. Similarly, Morten and Nohria (2004) identify four barriers to inter-unit collaboration: unwillingness to seek input and learn from others, inability to seek and find expertise, unwillingness to help, inability to work together.

2.4 Role of IT in collaboration

Clark, Croson and Schiano (2001) suggest a seven-stage model from independence to virtual integration while studying regularities occurring in technology-enabled inter-organizational relationships. Their seven levels of organizational interconnectivity include from bottom to top: physical data transfer, technology-supported document transmission, electronic data interchange, new information-intensive process and data sharing, new policies and integrated operations, joint optimization relationships, virtual channel integration.

In their seven stage model, information technology is believed to enhance collaboration levels but only under certain conditions. However, Lee, Pak, and Lee (2003) found that "*many suppliers and buyers who implemented B2B networks are still unwilling to cooperate or share data because of the fear that such information sharing could weaken their negotiating position with their channel partners*." These authors explain that maximum payoffs are only realized when information is shared adequately, which is inevitably linked to an increasing interdependency due to shared IT and business infrastructure. Similarly, the business process has to be reshaped so that IT can help increase the collaboration level. Similar concerns were raised by Teng *et al*. (1994)

3 Research questions and objectives

In this paper, we propose to study B2B practices and collaboration determinants throughout several echelon of the Québec forest products supply chain, which includes sawmills (timber first transformation), paper and cartons producers, furniture manufacturers and other value-added and building material producers. This study is thus not limited to retailer-supplier relationship as in Simatupang and Sridharan (2005). Furthermore, as proposed by Vereecke and Muylle (2006), this study involves the systematic analysis of both supplier and customer sides. The concept of collaboration is thus here not considered as being a construct describing the intricacy of business relationships; it is rather considered as an organizational construct, which qualifies the ability of an organization to develop collaborative ties with its supply chain partners. This perspective of collaboration can ultimately apply to an industry sector to characterize its B2B practices. This study proposes to do so in the Québec forest product industry.

3.1 Research questions

In this paper, three research questions are drawn from the above literature review:

- ✓ Can we determine a collaboration level and its underlying factors?
- ✓ Does this collaboration level significantly vary across the categories of the value chain?
- ✓ Do IT, age of companies, their size, internationalization, and position on the value chain play a key role in enhancing the collaboration level?

3.2 Objectives

The collaboration level as a construct with sound psychometric properties has been rarely measured from either the customer or supplier perspective. The first objective of this paper is to fill this gap. This study also proposes to contribute to the underlying factors of the collaboration level and its variation within an industry. A third objective is to assess the role played by information technology on the adoption of collaborative practices. While there is an extensive literature related to IT adoption, uses, perceptions, barriers and projects in the North American forest industry (Karuranga *et al*., 2005; Vlosky, 2001; Dupuy and Vlosky, 2000), no research has been devoted to the study of the impact it exerts on collaborative practices.

4 Research design and methodology

4.1 Questionnaire development and Data collection

In order to meet our objectives, we conducted a survey of forest products companies in the province of Québec, Canada. Our questionnaire was based on the abovementioned research questions, our objectives, and the existing literature related to the measurement of the collaboration level with its underlying factors. It was pre-tested with different forest industry professionals in Quebec. Company leaders were asked to separately assess their collaboration practices from both customer and supplier sides. The pretest phase yielded comments that enabled us to refine the final instrument in appendix A. This final instrument was distributed to 695 forest products companies in the province of Quebec. Valid responses were received from top executives of 312 companies. The 44.9% response rate is far beyond the commonly accepted standard in such surveys which usually ranges from 15 to 35%. In order to enhance the reliability of the 312 received valid responses, additional data and cross-validation information were gathered from public and professional databases including, the Canadian Ministry of Industry, *Statistique Québec* and *I-CRIQ* database.

4.2 Profile of respondents

The profile of respondents is presented in Figure 2 by age (i.e., year of creation) and position in the supply chain. As mentioned earlier, the forest products supply chain includes sawmills, pulp and paper mills, furniture manufacturers, and other value-added building materials, which includes doors and windows manufacturers.

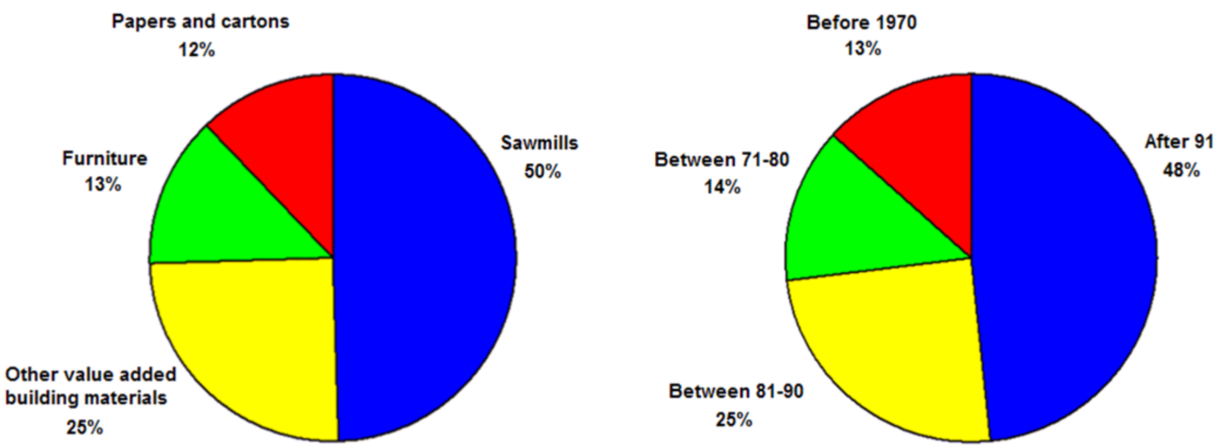

Figure 3: Profile of Respondents (sector and year of establishment)

4.3 Non-response bias test

Non-response bias test methods typically include a comparison of the distribution of respondents' and non-respondents' characteristics if and when they are known. Similar independent surveys can also serve as a base of comparison for selected characteristics. In this paper, data from the *I-CRIQ* database were used to compare respondents (n = 145) and non-respondents (n = 139) in the sawmill category, which is the largest group in our survey. A two-sample t-test, performed after verifying that the samples were similar in shape, showed no statistically significant response bias between the respondents and the non-respondents with regard to number of employees and year of establishment.

5 Data Analysis

5.1 Indices of collaboration

The collaboration level of each respondent is assessed in this study with the questionnaire provided in Appendix A. The B2B practices of both supplier and customer sides were used to assess collaboration levels. Instead of using a five-point scale, respondent were asked to state in “yes” or “no” answers what type of collaboration they have initiated with their suppliers and customers. Computed scores of “yes” answers show an evolutionary collaborative path with both customers and suppliers. This “yes” or “no” response approach is similar to the one proposed by Link and Bauer (1987) who used a dummy variable of the value 1 if the firm cooperate and the value 0 if the firm does not. To further improve the robustness of the construct, every “yes” response was assigned a value on a scale ranging from 0 to 4 referring to the position on the continuum. The scale itself is built from the aggregation of responses for each B2B practices where we assume that the higher the collaboration level, the less the number of “yes.” In other words, this approach assumes that collaborative practices are the most advanced B2B practices. Therefore, in a traditional industry sector such as the forest product industry, they are less likely to have been adopted by most companies, only by the most advanced of them.

5.2 Measurement model

In order to respond to the first research question, we developed a measurement model following two steps: an exploratory factor analysis and then a confirmatory factor analysis. The obtained results were used to respond to the second and the third research questions through a rigorous purification process. In the absence of an *a priori* theoretical model, we followed Schumacker and Lomax‘s (2004) recommendation and ran both exploratory and confirmatory factor analysis.

5.3 Exploratory factor analysis

The following constraining rules were applied to our exploratory factor analysis: Kaiser-Meyer-Olkin Measure of Sampling Adequacy must be bigger than 0.80, communalities extraction must be bigger than 0.50, variance explained must be bigger than 0.50, factor loading must be bigger than 0.50, double loading must be bigger than 0.50, and single loading for sake of parsimony. Varimax rotation with Kaiser normalization was applied with Eigen-values larger than 1. We calculated a correlation matrix in a search for multicollinearity. Internal reliability of our constructs was assessed using Cronbach's alpha coefficient bigger than 0.70.

5.4 Confirmatory factor analysis

In order to confirm the factor structure generated at the exploratory level, a confirmatory factor analysis was conducted following Byrne's (1994) recommendations. To avoid measurement biases while assessing the degree to which the data fit the model, Browne and Cudeck (1993) and Hu and Bentler (1999) recommend numerous fit statistics structural equations models. We used the most cited indices to assess the fitness of our model to the 312 companies in the survey:

- the ratio of chi-square to degree of freedom (χ^2/df): an acceptable range is met between 2 and 3 (Carmines and McIver, 1981). Some conservative schools put the chi-square/df ratio to less than 2.00 with an insignificant *P*-value (e.g. P>0.05) (Byrne, 1994). Hartwick (1994), Hair *et al*., (1995) and Chau (1997) recommend a maximum of 3.0;
- the root mean-square residual (RMR) which compares the values of variances and covariances predicted by the model with the variances and covariances obtained from the data to detect discrepancy between the two, thus zero representing a perfect fit;

- the root mean square error of approximation (RMSEA) with value close to 0.06 or better. Schumacker and Lomax (2004) recommend 0.05 or less for the RMSEA in terms of providing a good fit of the data;
- the standardized root mean square residual (SRMR) with value close to 0.08 or better (Hu and Bentler, 1999);
- the comparative fit index (CFI) with value close to 0.95 or better (Hu and Bentler, 1999);
- goodness-of-fit index (GFI) which ranges from zero (no fit) to one (perfect fit).

6 Results and discussions

6.1 Exploratory factor analysis

As shown in Table 1, an exploratory factor analysis performed using SPSS 11.00 yielded three distinct factors. Customer and supplier items loaded separately with the exception of joint investments on both sides loading in a separate dimension. A reliability analysis was conducted for the three factors. As shown in Table 2, deleted items include exchange of performance evaluation for low extraction. Furthermore, Joint new products development, resource sharing, and implementation of replenishment systems are suppressed for highly loading on two distinct factors. Deleted items appear to be those generally consider as being the most advanced forms of collaborative practices, which indicates a rather poor level of collaboration for the forest product industry. To further validate the robustness of our instrument, Table 1 presents the Cronbach's alfa coefficient. As shown in Table 3, no multicollinearity was detected in the correlation matrix as all coefficients are inferior to 0.85 with a minimum of 0.10. The output shows a coefficient of 0.81 for supplier side items and 0.80 for those on the buyer side. These rates are higher than the commonly accepted level of 60% for such an exploratory study (Flynn *et al.*, 1990). Hence, joint investments both at the supplier and client sides were dropped for poor reliability (0.54).

Table 1: Exploratory Factor Analysis

Kaiser-Meyer-Olkin Sampling Adequacy	0,86	6.1.	6.1.
Rotated Component Matrix.	Factor 1	Factor 2	Factor 3
z37e Joint planning	**0.74**	0.14	0.16
z37g Joint delivery improvement	**0.73**	0.16	0.11
z37b Exchange of basic information	**0.72**	0.23	-0.12
z37f Exchange performance evaluation	**0.67**	0.06	0.30
z37c Resources sharing of logistic assets	**0.66**	0.12	0.20
z37a Joint sales forecasting	**0.63**	0.24	-0.07
z35b Exchange of basic information	0.09	**0.78**	-0.03
z35a Joint sales forecasting	0.14	**0.71**	-0.06
z35e Joint planning	0.14	**0.70**	0.15
z35h Joint new products development	0.07	**0.68**	0.11
z35g Joint delivery improvement	0.26	**0.62**	0.06
z35d Replenishment systems	0.31	**0.58**	0.17
z35i Joint investment	0.05	0.20	**0.79**
z37i Joint investment	0.20	0.00	**0.77**
Alfa Cronbach's Coefficient calculated on items in bold	0.81	0.80	0.54

Table 2: Deleted items

Deleted items	**Level of deletion**	**Reason**
z35f Exchange performance evaluation	1st iteration	extraction<0.5
z37h Joint new products development	2nd iteration	double load.>0.5
z35c Resources sharing of logistic assets	2nd iteration	double load.>0.5
z37d Replenishment systems	2nd iteration	double load.>0.5
z37j Vendor Managed Inventory	3rd iteration	extraction<0.5
z35i Joint investment	reliability analysis	Cr. alfa <0.7
z37i Joint investment	reliability analysis	Cr. alfa <0.7

Table 3: Multicollinearity Analysis

Inter-items Correlation Matrix	z35 a	z35 b	z35 d	z35 e	z35 g	z35 h	z35 i	z37 a	z37 b	Z37 c	z37 e	z37 g	z37 i	z37 f
Collaboration with customers														
z35a Joint sales forecasting	1.00													
z35b Exchange of basic information	0.51	1.00												
z35d Replenishment systems	0.37	0.41	1.00											
z35e Joint planning	0.41	0.43	0.42	1.00										
z35g Joint delivery improvement	0.35	0.40	0.34	0.43	1.00									
z35h Joint new products development	0.33	0.43	0.37	0.37	0.40	1.00								
z35i Joint investment	0.11	0.14	0.19	0.22	0.18	0.18	1.00							
Collaboration with suppliers														
z37a Joint sales forecasting	0.32	0.18	0.30	0.25	0.22	0.19	0.12	1.00						
z37b Exchange of basic information	0.26	0.30	0.21	0.25	0.23	0.23	0.10	0.52	1.00					
z37c Resources sharing of logistic assets	0.16	0.20	0.36	0.22	0.25	0.10	0.18	0.30	0.41	1.00				
z37e Joint planning	0.16	0.16	0.31	0.24	0.33	0.21	0.19	0.41	0.46	0.39	1.00			
z37g Joint delivery improvement	0.15	0.20	0.34	0.19	0.38	0.21	0.15	0.35	0.44	0.42	0.55	1.00		
z37i Joint investment	0.07	0.05	0.15	0.11	0.06	0.11	0.37	0.15	0.13	0.22	0.24	0.20	1.00	
z37f Exchange performance evaluation	0.17	0.13	0.30	0.20	0.22	0.13	0.22	0.31	0.36	0.47	0.46	0.10	0.27	1.00

Before submitting the retained items to a confirmatory factor analysis, the univariate distribution normality test was conducted. In a CFA using maximum likelihood as an estimation method, acceptable skewness and kurtosis levels for a normal distribution are respectively set bigger than 2 and bigger than 7 (West, Finch, and Curran, 1995). Skeweness and kurtosis coefficients for items in this study meet the recommended limits.

6.2 Confirmatory factor analysis

Although univariate distribution satisfies conditions for an estimation by the maximum likelihood method, we use diagonally weighted least square (DWLS) as suggested by Flora and Curran (2004) and Jöreskog and Sörbom (1996) whenever a stable parameter estimator is needed for small samples.

We started with separate first order confirmatory models for each side (supplier and customer). Using LISREL 8.71, the two models were then combined in one measurement model with covariance between both sides. The combined measurement model is depicted in Figure 3. Next, a second order confirmatory factor analysis was ran in order to assess the relative contribution of each side to the collaboration level. Results of second order CFA are shown in Figure 4. All final models were retained after rigorously checking for residuals and modification indices using a step by step modification procedure starting by residual matrices followed by modification indices before deleting any non-significant parameter. The final models fit indices (displayed in Table 4) exceed the generally accepted standards, thereby confirming that our model fits the data very well.

Figure 4: First Order CFA

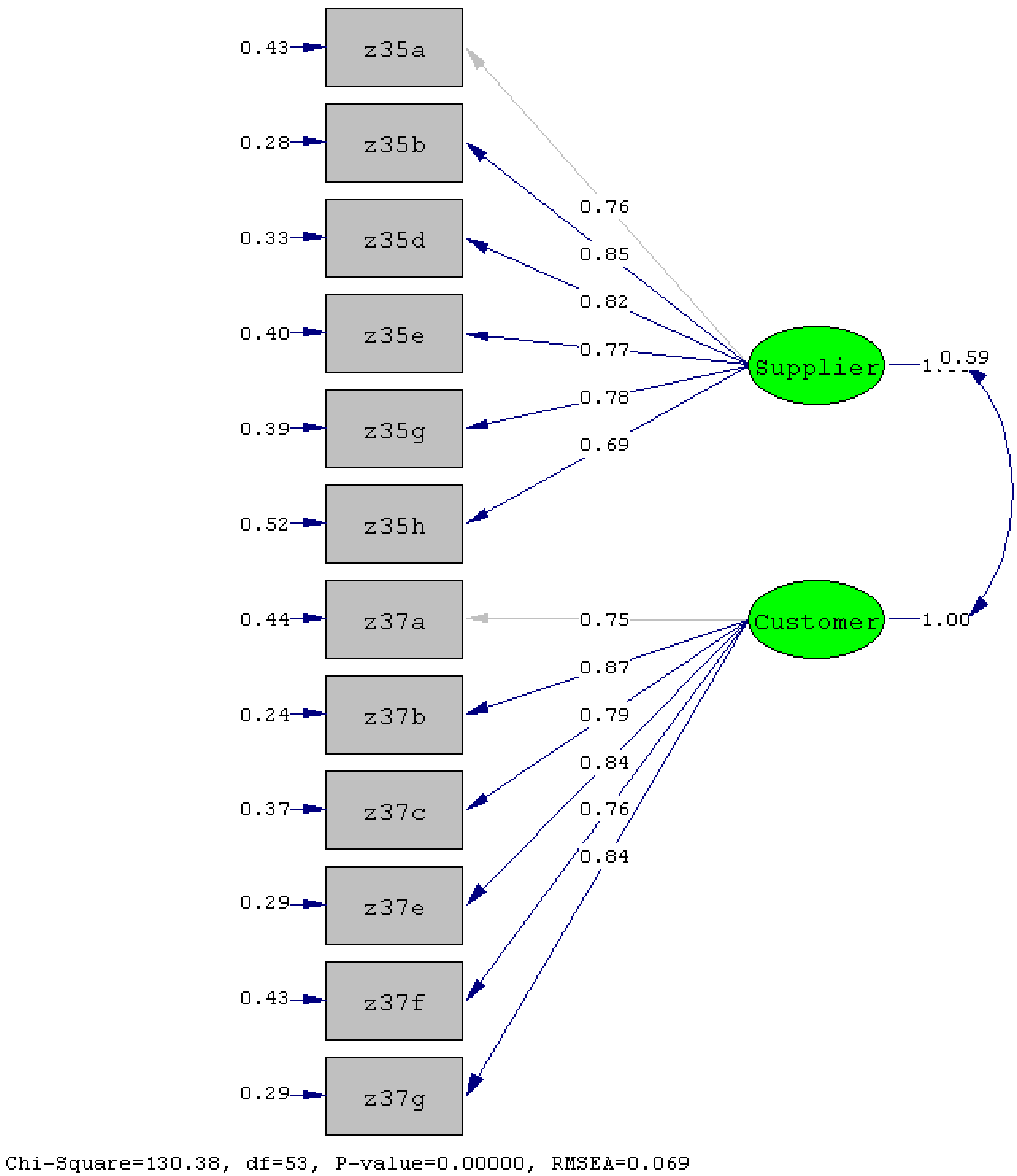

Figure 5: Second Order CFA

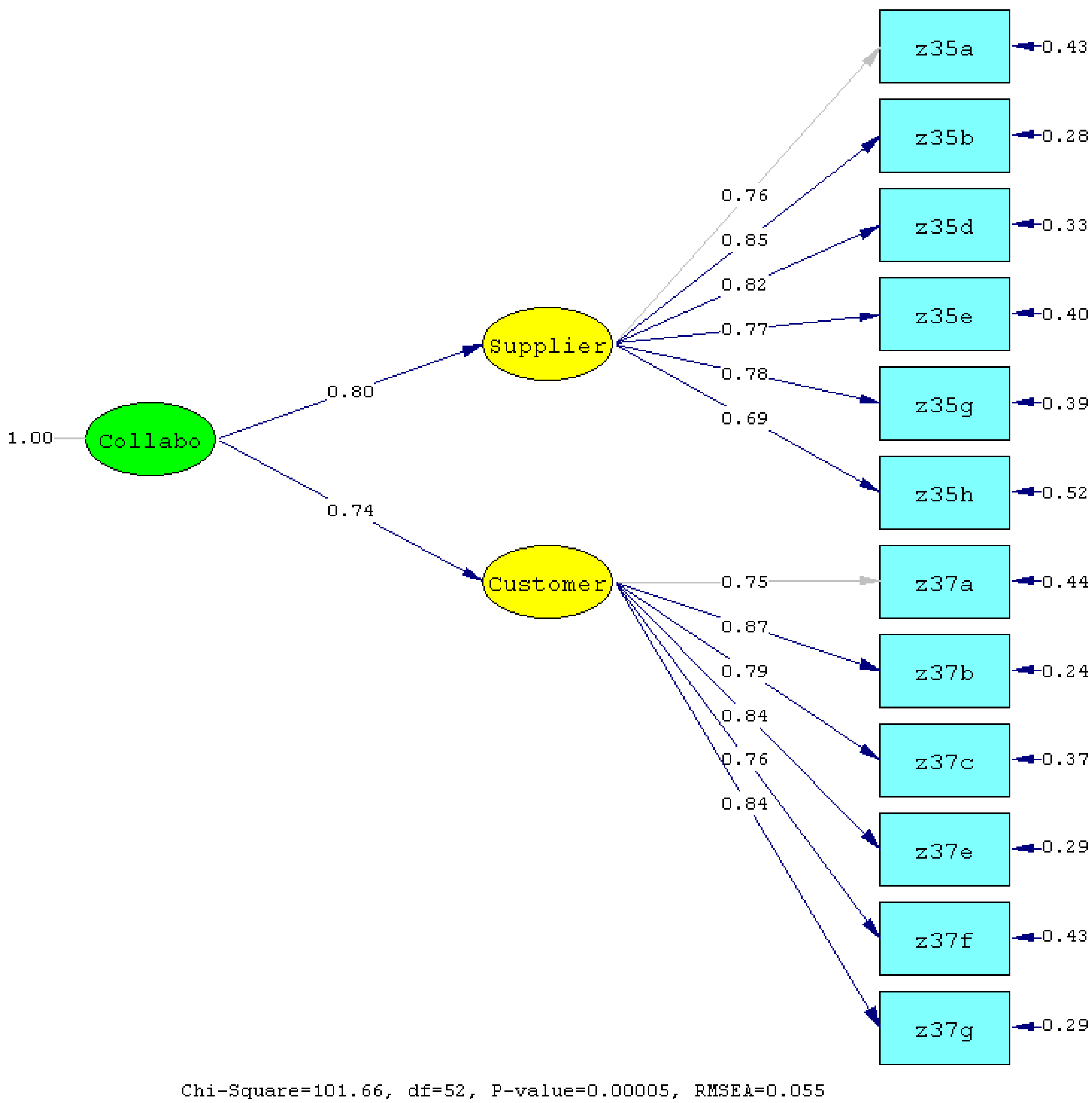

Table 4: Measurement Models Fit Indices

	Chi2	df	Chi2/df	P-value	RMSEA	CFI	SRMR	GFI
1st order CFA	130.38	53	2.45	0.00000	0.069			
2nd order CFA	101.66	53	1.92	0.00005	0.055			
Desirable level			2 - 3		0.060	0.95	0.08	0 - 1

6.3 Testing the validity of the model

In order to test the internal validity of a model, structural equations models often rely on content, convergent, discriminant criteria, and nomological validities. In this study, content and face validity encompassing wording and phrasing was met at the pretest stage of the questionnaire. An external validity assessment can be conducted in four different ways: by simulating the results to meet the real world situation, by testing the model with a new sample, by randomly splitting the original sample in two new samples to be tested with the same model and by bootstrapping the results in search of parameter estimates variations (Byrne, 1994; Schumacker *et al.*, 2004)

Firstly, convergent validity is generally achieved when factor loadings are bigger than 0.50 (Kline, 1998). This common rule of loading is met as all items in all the final models show values greater than 0.50. A second criterion for convergent validity is the variance extracted by every factor whose recommended threshold is 0.50.

Secondly, to assess discriminant validity, correlations of the factors underlying the set of indicators were calculated to ensure that constructs can be empirically differentiated from each other. Limits are usually set between 0.10 and 0.85 (Kline, 1998) for a good discriminant validity. Our results show that none of the correlation coefficients exceeds the recommended limits. Moreover, each item loads stronger on its associated factor than on any other factor.

Third, to examine criterion validity of the two constructs in the second order factor analysis model, we estimated a regression model between them as independent variables and the overall collaboration as a dependant variable. Both constructs are significant and exert positive influence on the overall collaboration concept as a dependent variable. Fourth, in the absence of previous studies, nomological validity could not be assessed. It usually determines if an instrument behaves as it should when compared to empirical literature.

As to external validity aiming at testing the replicability of our results, the two factor model was randomly split into two samples using SPSS. A first order CFA using LISREL 8.71 and DWLS as estimating method was run on the two randomly split samples (n1= 156., n2= 156). Results reported in Table 5 show similar goodness of fit indices in all 3 samples. Compared to the 1st order CFA model, these fits show no statistically significant difference.

Table 5: External Validity

Fit indice	Sample 1 model N=156	Sample 2 model N=156	1st order CFA model N=312
Chi-square	**76.26** (*P =0.020*)	**98.73** (*P= 0.00014*)	**130.382** (*P = 0.000*)
Df	53	53	53
NFI	0.97	0.96	0.975
CFI	0.99	0.98	0.985
GFI	0.99	0.98	0.986
RMSEA	0.053	0.075	0.0685

6.4 Collaboration as a multi item construct

Results obtained from section 6.1 to 6.3 of this paper indicate that collaboration in the forest products industry can be defined by four items shared by both customer and supplier sides and 2 items specific to each side. The four items which are common practices on both sides are joint sales forecasting, exchange of basic information, joint planning, and finally, Joint delivery improvement. Two practices are highly oriented towards customers: resources sharing of logistic assets and exchange of performance evaluation. B2B Practices engaged mostly with suppliers include the implementation of replenishment systems and Joint new products development.

6.5 Testing invariant structure

Our third research question refers to model validity across groups in the sampled population. To test this, we conducted an invariant structure analysis across the groups of companies according to the following criteria using a comparison of correlation matrices: exporting firms versus the rest, year of establishment to compare young companies established after 1991 to older ones, position in the supply chain, having a website or not, interacting using IT or not, and number of employees as a proxy of size. All the correlation matrices were found to be equal, thus the null hypothesis cannot be rejected. At *p-value =0.05*, there is no statistically significant difference as reported in Table 6. This confirms a high level of similarity in the low collaboration intensity across the forest products industry. More specifically, IT does not seem to influence the collaboration level in the forest products industry.

Table 6: Invariant Structure Analysis

	Chi-Square	p-value
Having a website (n=196) versus no website(n=116)	85.123	0.272
Interacting via IT(n=168) versus non interacting (n=144)	75.606	0.556
Export (n=172) versus non export (n=140)	69.062	0.755
Number of employees: 141 large companies versus 171 small ones	77.953	0.480
Domain of activity : 145 sawmills versus 167 other companies	78.238	0.471

7 Conclusion, Limitations and Future Research

Collaborative practices are constantly evolving within and between networked companies. The forces behind this move include IT, industrial culture, size of companies, location, etc. However, to the best of our knowledge the level of collaboration as such and its underlying factors had never been measured, at least at the time we conceived and conducted this survey. We developed a method to fill the gap and stimulate the debate on collaboration construct measurements. Therefore, the main theoretical contribution of this study remains the development of a measurement model of collaborative practices in organizations building on the example of the Quebec forest products industry. Practices are categorized into those which are common to customers and suppliers and those which are specific to either of these two sides.

In this study, we also focused on relationships within one sector: the forest products industry. The overall results show a sector rather less prone to collaborating based on indices of collaboration. There is an apparent strong industrial culture which is likely not in favor of high levels of collaboration as invariant structure tests across different grouping criteria yield no statistically significant differences.

As to the practical implications, through the above categorization of collaboration indicators, managers will find useful indications of how to assess their collaborative practices. Potential marketers of IT products as well as public institutions will find some key areas that need products and services to improve collaborative practices in the industry. Hardware and software companies should also exploit the results if they want to enter the untapped e-supply chain management market in the Quebec forest industry.

However, despite the above theoretical and practical contributions, some limitations are discernable. First, the number and quality of interviewed persons could be extended to cover all staff levels of the surveyed organizations. Data should be collected on their personal characteristics. These data would extend to age, training, previous experience and position in the organization. The types of tools used to collaborate should also receive more attention in future studies. As to IT, although weak and with little impact on collaboration levels, its adoption rates and subsequent collaboration practices enhancement might also have been influenced by other external actors which potentially include public and private institutions. Investigating ties with these external organizations could help in predicting the successful implementation of any innovation at home as Granovetter, (1985) states. Therefore, extending future research to the level of collaboration with additional actors will certainly bring in more plausible explanations as to why the forest product industry is lagging behind in both IT and collaboration practices.

Future research should also concentrate on the role played by the history of the forest industry firms and determine at what extent it is correlated with the low collaboration levels previously mentioned. Barney (1991) emphasized experience acquisition and accumulation through time. Past capabilities of changing routines is a key indicator as to how new technology and ideas will be adopted.

Similarly, an interesting avenue for future research is the comparison of the pre adoption status and the post adoption results, thus assessing the role of IT impact on collaborative practices. Such a longitudinal research could also reveal how successful IT tools are implemented at different companies in order to boost collaboration levels.

The agenda of future research could also include the following issues:

- standardization of practices within the industry and harmonization of channels
- internal cooperation between departments of the organization under study as mentioned by Kim (2001) and Stank et al. (2001);

- commitment, trust, culture, social embeddings of knowledge;
- type of technology used to enhance collaborative practices.

Finally, one of the potential sources of conflicting findings in quantitative research is the reliance on highly contextual studies which yield non-generalizable results. Using our validated constructs under different settings will further enhance their validity.

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Appendix A: Survey Questions

Respondents were asked to answer “yes” if they had implemented these practices, “no” if not.

Customers side	Suppliers side
Joint sales forecasting (q35a), Exchange of basic information (q35b), Resources sharing of logistic assets (q35c), Replenishment system (q35d), Joint planning (35e), Exchange performance evaluation (q35f), Joint delivery improvement (q35g), Joint new products development (q35h), Joint investment (q35i)	Joint sales forecasting (q37A), Exchange of basic information (q37B), Resources sharing of logistic assets (q37c), Replenishment system (q37d), Joint planning (37e), Exchange performance evaluation (q37f), Joint delivery improvement (q37g), Joint new products development (q37h), Joint investment (q37i), Vendor Managed Inventory (q37j)

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