RESEARCH ARTICLE OPEN ACCESS

Sustainable supplier selection: the effect of logistical collaboration on logistical performance

José Geraldo Vidal Vieira*, Ricardo Coser Mergulhão**
*(Department of Production Engineering, Federal University of Sao Carlos, Brazil)
**(Department of Production Engineering, Federal University of Sao Carlos, Brazil)

ABSTRACT
This research assesses the effect of buyer-supplier collaboration on logistical performance by considering sustainable criteria. The paper presents the results of a survey with 124 respondents of the Brazilian organizations to understand the relationship among Third-Party Logistical (3PL), Consumer Packaged Goods (CPG) industry and Carriers. The results disclose that elements of logistical collaboration (interpersonal, tactical and strategic) exert positive influence in logistical performance (reliability, transport and risk). The interpersonal and strategic collaboration indices positively influence the reliability, which performs the highest-level performance index.
Keywords **-** Buyer-supplier relationship, Collaboration, Logistical performance, Supplier selection, Sustainable criteria

I. INTRODUCTION

The logistical service provider that strives for high logistical performance depends on collaboration or integration with their supply chain partners to improve activities, such as transportation, warehouse services and distribution [27,30].

The logistical performance in this context refers an organization's ability to provide goods and services in the quantities and time limits required by retailers [12,17,40]. Furthermore, [7,39] highlight the multidimensionality of logistical performance involving a wide range of indicators for different purposes.

The authors [39] have analyzed many research related to dyadic buyer-supplier relationship and concluded that the majority of survey research presents a positive impact of collaborative relationship on performance, however argue that it is questionable whether the nature of this relationship is well understood as well as the real impact of the relationship on the performance. This research attempts to contribute in this field.

Additionally, according to [31], strategic long-term relationship (i.e. in this paper referred as collaboration) and logistical performance are also related to supplier assessment as well as many others regarding criteria supplier selection [33,34]. In this regard, [1] have developed a fuzzy model base on sustainable criteria which related economic sub-criteria to logistical performance. The authors [22] also have described a fuzzy model considering many variables to select green suppliers in supply chain. In that way, sustainable criteria to contract transportation from carriers and warehouse and Information Technology (IT) services from Third-Party Logistical (3PL) or global companies have been considered recently as reviewed by [18]. This research also focuses on inter-firm relationships among 3PL and their partners, such as Consumer Packaged Goods (CPG) and transporters services providers. The author [38] emphasizes the importance of 3PL in supply chain collaboration.

It is expected that logistical collaboration among companies inside the green supply chain provides an opportunity to study the aspects of sustainable practices regarding logistical services and may contributes to sharing of logistical costs and gains. In fact, the environmental impact of logistical activities has been the subject of specific studies, as shown by [35].

The main contribution of this research is to answer the question "which logistical collaboration indexes contribute to a high logistical performance among retail sector partners, given sustainable criteria"? The purpose is to create indexes to assess the impact of logistical collaboration among the 3PL and their partners on logistical performance.

This paper presents the collaborative and performance indicators associated with some less important aspects of the environmental performance inside the retail chain that may green the supply chain. In addition, highlight a number of specific drivers that have not been addressed earlier in the empirical literature. Therefore, this paper focus on some attributes based on logistical collaboration, buyer–supplier collaborative relationships have discussed mainly by [13,42] as well some sustainable criteria to supplier selection. Other aspects such as supplier assessment and specific environmental issues are out of scope, notwithstanding their

importance for future research. This paper is organized as follows. Section II describes the theoretical background based on relevant studies. Section III describes the hypotheses and the research model regarding the positive effect of logistical collaboration on logistical performance and the positive correlation between transport and the selected supplier with sustainable practices. Section IV describes the methodology employed in our empirical research sample and the associated procedures, data analyses and variables. Section V presents our main findings with regard to the indices that were created to evaluate the impact of collaboration on logistical performance by regression analysis and regard to the analysis between supplier selection and transport logistical performance. This covers various dimensions and aspects, and takes into account the possible interactions between the different dimensions. Section VI presents our main conclusions.

II. THEORETICAL BACKGROUND

The importance of investigating collaboration and performance in the Green Supply Chain context have been supported by several authors [15,19,22,33,43,44].

Hence, this importance has caused the supply chain players to pursue more actions related to carbon emission reduction [9] and to develop a good measuring system for supplier performance [10,26,29] and to supplier/partners selection criteria [43]. Some of them is comprised of high performance delivery [21], transportation management systems [14] and backhaul failure. These aspects have led firms to collaborate with greater logistic efficiency and with lower economic-environmental costs. Therefore, all firms must consider environmental issues in their business process.

The term "environmental aspects" first gained special prominence in the report "Our Common Future" ([6], p. 54-55). In this line, according to a literature review by [27], the aim of a sustainable transport should be consider minimizing logistical cost and environmental impacts and maximizing efficiency. It could also be referred to as the triple-P: planet (CO_2 emission, the use of non-renewable natural resources), people (physical consequences of pollutant emissions on public health, the increase in nuisance) and profit (decrease in journey reliability and delivery punctuality, potentially resulting in less service to customers and lost markets). This research highlights the profit.

III. HYPOTHESES AND RESEARCH MODEL

Logistical collaboration occurs when two or more organizations form a coalition and share resources, such as information, with the purpose of making decisions or performing activities that generate mutual benefits [3].

The authors [42] have grouped the collaboration elements into three theoretical factors: strategic, tactical and interpersonal. The collaboration in this research is based on these elements that may influence the operational logistical performance. It is notable that the collaboration and logistical performance indexes reveal what to improve in transactions. The hypothesis and research model are detailed below in two steps.

Firstly, collaboration helps the construction of organizational abilities through information and knowledge exchange regarding what facilitates the best performance of partners [11]. Following [24], logistical performance improves when partners are aligned in the search for a common strategy. According to these authors, partner performance is positively influenced by incentives and rewards that may determine individual behaviors. According to [5], collaboration provides benefits such as information sharing; reduced costs and logistical risks; performance boosts; and joint synergies among parts. Information sharing and inter-organizational relationships are based on interpersonal characteristics [4], while certain aspects of collaboration focus on human and financial resources and on logistical operations. According to [37], external collaboration more positively influences logistical performance if each partner already has its own functional areas aligned with respect to information sharing (i.e., internal collaboration). The authors [12] defend that the suppliers of the green supply chain may influence partners toward a better performance. The partners that establish a long-term relationship may acquire environmental competence [19]. According to [15], this long-term relationship facilitates improved environmental performance.

Secondly, according [31], several studies have examined empirically the criteria for supplier assessment. Based on literature review the authors have revealed that quality, delivery, and service are the most important assessment criteria besides costs. Consequently, some researches have shown a positive correlation between the assessment of a supplier's delivery and quality performance [23].

The authors [43] present a portfolio-based analysis of green supplier management and of the assessment criteria for supplier performance as an important addition to assess the relationship among partners. The elements are strategic performance measures (cost, quality, time, flexibility, process management, and innovativeness), organizational factors (culture, technology, relationship) and environmental factors (pollution controls, pollution prevention, environmental management systems, resource consumption, and pollution production). Some sustainable practices have already been

conducted in this scenario such as the selection of logistical services with low air emissions (mainly carbon emissions) [32], the selection of a project and the reduction of package size [12], the choice of transportation, a load optimizing and lower transportation cost [14], vehicle availability and flexibility [20] and the perceived quality of transport. This research addresses on the last aspects. According to [43], specific environmental requirements are important to evaluate the impact of sustainable practices on environmental performance. Therefore, the literature review indicates that when a supplier has a good logistical performance with respect to green transport, it may be selected by its partners because it adopts sustainable practices, and vice versa. Thus, the following related hypotheses are made:

H1 - An increase in collaboration contributes to better logistical performance.

H2 -There is a positive correlation between a high green transport performance and the suppliers selected by sustainable practices.

These hypotheses have been relevant to develop the following research model. The positive influence of logistical collaboration upon logistical performance (H1) and the correlation between green transport and the selected supplier with sustainable practices (H2) are shown in Fig. 1. In this paper, the term "Transport" considers the efficiency and construct of the transportation selected.

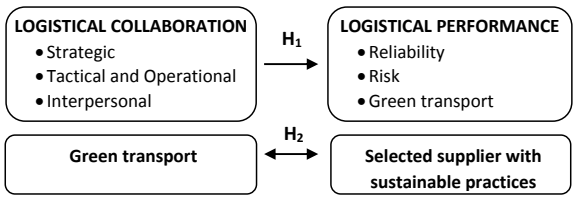

Figure 1: Research framework

IV. METHODOLOGY

Sample and procedures

The data for this study was drawn from managers of Brazilian manufacturing and Logistical Service Provider firms via Survey Monkey electronic platform that was conducted between end of 2012 and early 2013. The list of the respondents was randomly selected from a mailing list of the large 3PL and a database used in the last project concerning collaboration in retail supply chain carried out by [42]. In total, roughly 2200 surveys were mailed out, and 124 usable responses were received; hence, the response rate is 6.88%. The data were checked for bias using correlations of responses between early respondents and late respondents [2] based on type of industry and annual revenue (firm size). The chi-square tests on both categories indicated no significant difference between the two groups of respondents.

The survey was developed based on the study of [8], which suggested seven stages for an iteration-and-looping design. This survey was compiled from various validated instruments from the literature and several pre-tests to evaluate the final instrument. [16] advises that in the pre-test, the surveys should be sent to three types of individuals in the study's target population: research colleagues, experts and organizations. The same author also notes that the first category of individuals helps to verify the survey's alignment with the study's objectives.

The second category helps to prevent the exclusion of obvious and important questions. In this case, it was validated by two managers of a large 3PL. Finally, the last category provides feedback concerning contingencies that may affect data collection. The three final models were developed and applied to different firms through the Survey Monkey electronic platform to assess their partners as follows:

- 3PL: the chosen partner should be in the transport or CPG industry;
- Carrier: the chosen partner should be in the 3PL or a CPG industry;
- CPG industry: the chosen partner should be a 3PL or Carrier.

We highlight that each respondent had to choose one of their partner, and then evaluated collaboration, logistical performance indicators and the supplier selection based on sustainable criteria. As each interviewee could evaluate a different partner, observations were independent, although based from the same company. Thus, two factors should be considered: (a) the difference in the respondents' perception of the same partner may reveal differences in opinion in the relationship with different ones, and (b) each interviewee occupy different positions (directors, managers, coordinators and logistics analysts), and have distinct experiences working for the same company.

Measures

The Likert scale, which ranges from zero (lowest) to 10 (highest), was used to measure the collaboration and logistical performance indicators, and the supplier selection elements. The Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), as well as the Likert scale from 1 to 7 were also tested. The test results have noted that interviewees felt more comfortable assessing the construct on the 0-10 scale. Additionally, the time required to answer was much lower than it was for other Likert scales.

Data Analyses

Based on the literature, the constructs of our model are "Strategic", "Tactical" and "Interpersonal" for the collaboration elements, and "Transport", "Reliability" and "Risk" for the logistical performance elements.

A factorial analysis was employed to reduce the number of original variables of the collaboration and logistical performance constructs. After extracting the factors, indices were derived from the weighted means of the aspects evaluated by the factor loads of the rotated components matrix. These indices allow the use of linear regression analysis to measure the effect of collaboration on logistical performance. Thus, the logistical performance elements were used as dependent variables, and the collaboration elements were used as independent variables in the regression.

The software SPSS® (Statistic Package for Social Study, version 20.0) has been used to conduct the factor analysis to build indices and to show the regression models and the correlations.

V. RESULTS AND DISCUSSION

Sample characterization

The characteristics of the respondents of the Brazilian organizations are presented in Table 1.

The type of industry is uniformly distributed among CPG, Carrier and Third party Logistical. The industrial sector is homogenously distributed in the food and drink, vehicle spare parts, telecommunication/energy, electronic, hygiene, chemical, and chemist categories, and half in the miscellaneous category. The majority of the samples consists of long-term relationships (i.e. higher than three years - 83 responses) and domestic (67 responses) and different sizes of companies represented by annual revenue. Therefore, it is shown that the sample did not exhibit any problems and is represented by firms of several industries from three sectors (CPG, Carrier and Third party Logistical) and sizes.

Table 1: Profiles of the respondents of the Brazilian organizations

Control variables	Categories	Frequency	Percentage of respondents of the firms in the sample	Percentage of respondents of the firms that measures CO_2
Type of industry	CPG	40	32.3%	42.0%
	Carrier	33	26.6%	39.4%
	Third party Logistical	51	41.1%	45.1%
Industrial sector	Food	08	6.5%	37.5%
	Automotive	09	7.3%	*22.2%
	Electric and Electronic	06	4.8%	*16.7%
	Chemical	16	12.9%	37.5%
	Technology/Telecom	04	3.2%	50.0%
	Miscellaneous	69	55.6%	50.7%
	Others	07	5.6%	57.1%
	Non-respondents	05	4.0%	0.0%
Annual revenue (million $US)	< 9	19	15.3%	42.1%
	9 – 170	28	22.6%	39.3%
	> 170	24	19.4%	*33.3%
	Non-respondents	53	42.7%	0.0%
Long-term relationship	< 3 years	41	33.1%	39.0%
	3 - 5 years	31	25.0%	38.7%
	> 5 years	52	41.9%	48.1%
Owner capital	Domestic	67	54.0%	43.3%
	Foreign	53	42.7%	45.3%
	Non-respondents	04	3.2%	0.0%

Another aspect to be noted in Table 1 is that some respondents of the firms state that some firms with specialized characteristics emit less CO_2 (last column) than firms without specializing characteristics. For example, the automotive industry has a low CO_2 measurement, followed by the electrical and electronics industry.

Collaboration and logistical performance indices

A factorial analysis was employed to reduce the number of variables in the two groups (Collaboration and Logistical performance). These variables are correlated to each other and are represented by some factors or main components. To verify data adequacy, Bartlett's test of sphericity was conducted and was found to be significant at 1 percent for both groups (with 124 observations), thus rejecting the null hypothesis that the correlation matrix is an identity matrix. The Kaiser-Meyer-Olkin (KMO) test yielded

a value of 0.897 for Collaboration and 0.895 for Logistical performance. Additionally, the number of variables analyzed in each group (19 and 12, respectively), when compared to the observation numbers, comply with factorial analysis requirements.

The main components method has been used to extract the Collaboration and Logistical performance factors, assuming that the percentage of the total variance explained by the factors was a criterion to determine the number of factors. Table 2 (collaboration factors) and Table 3 (logistical performance factors) show the distribution of the original variables in the respective extracted factors (i.e., CO1, CO2, CO3, LP1, LP2 and LP3) with Cronbach's α, factorial loads, communalities, and the percentage accumulated variance of the two groups of factors.

Table 2: Extraction of the collaboration factors

Factors extracted	Original variables - Collaboration	Factorial loads			Communalities
CO1	Inter-organizational trust	**0.891**	0.058	0.259	0.864
	Interpersonal trust	**0.870**	0.174	0.278	0.865
Interpersonal	Commitment	**0.828**	0.278	0.171	0.793
collaboration	Flexibility	**0.734**	0.276	0.269	0.687
(Cronbach's α = 0.91)	Reciprocity	**0.625**	0.541	0.240	0.740
	Interdependence	**0.531**	0.129	0.419	0.474
CO2	Sharing information of volume changes	0.189	**0.877**	0.234	0.833
Tactical	Sharing information of final destination data	0.152	**0.841**	0.321	0.859
collaboration	Sharing information of specific events	0.182	**0.839**	0.257	0.802
	Joint planning of specific events	0.577	**0.651**	0.171	0.659
(Cronbach's α = 0.90)	Transparency in communication	0.241	**0.628**	0.455	0.786
	Team dedicated to each logistical project	0.308	**0.529**	0.514	0.639
	Joint planning of vehicle demand	0.306	**0.373**	0.469	0.453
CO3	High management involvement	0.197	0.108	**0.814**	0.713
Strategic	Establishment of new joint logistic projects	0.285	0.252	**0.793**	0.773
collaboration	Sharing joint logistic goals/plans	0.194	0.381	**0.786**	0.801
(Cronbach's α = 0.88)	Joint logistical projects	0.136	0.473	**0.704**	0.738
	Knowledge of difficulties and strategies	0.358	0.279	**0.584**	0.547
	Shared risk (theft and other losses)	0.301	0.195	**0.525**	0.404
Percentage variance explained		**53.76**	**9.81**	**7.11**	
Percentage accumulated variance		**53.76**	**63.57**	**70.68**	

It was verified that CO1 (i.e., interpersonal collaboration) presented the highest percentage of the total variance explanation (53.764 percent). The paper [42] found the similar result, closely followed by CO2 (i.e., tactical collaboration) and CO3 (i.e., strategic collaboration). The total variance explanation of collaboration is 70.681 percent. Four of the 23 collaboration variables were eliminated because of low communality. Furthermore, the "joint planning of vehicle demand" variable was initially classified as a CO3 factor. Considering that this load was homogenously distributed among the three collaboration factors and is supported by the collaboration theory, it was subsequently considered a CO2 factor.

Similarly, in Table 3, LP1 (i.e., reliability) presents the highest percentage of the total variance explanation (55.364 percent), followed by LP2 (transport) and LP3 (risk). The total variance explanation of logistical performance is 78.080 percent. One of the 13 logistical performance variables was eliminated because of low communality and the "Deliveries in periods of high demand" variable presented the load shared between LP1 and LP2 with a higher level in LP2. Consistent with theory, this variable has a greater significance in LP1. The results of the factor analysis permitted the identification of the variables in factors that explained collaboration and logistical performance, though some variables were eliminated or reclassified within the factors.

Table 3: Extraction of the logistical performance factors

Factors extracted	Original variables – Logistical performance	Factorial loads			Communalities
LP1	Fulfillment of scheduled delivery	**0.880**	0.274	0.218	0.897
Reliability	On-time delivery	**0.873**	0.328	0.136	0.888
(Cronbach's α = 0.91)	Order and delivery without mistakes	**0.823**	0.249	0.244	0.799
	Urgent deliveries	**0.739**	0.163	0.264	0.643
	Lead time to delivery	**0.678**	0.569	0.168	0.812
	Deliveries in periods of high demand	**0.501**	0.649	0.135	0.690
LP2	Vehicle external appearance/cleanness	0.064	**0.871**	0.123	0.778
Transport	Short distance-routing	0.317	**0.784**	0.074	0.720

(Cronbach's α = 0.82)	Vehicle availability	0.339	**0.756**	0.137	0.706
LP3	Shipment theft	0.029	0.028	**0.912**	0.833
Risk	Damaged delivery	0.356	0.198	**0.792**	0.794
(Cronbach's α = 0.84)	Returned deliveries	0.404	0.198	**0.780**	0.810
Percentage variance explained		**55.36**	**13.66**	**9.05**	
Percentage accumulated variance		**53.36**	**69.03**	**78.08**	

Based on the variables' factor load indices, the factors in the Table 2 and 3 might be aggregated into an index to measure the intensities of collaboration and logistical performance. Therefore, after factor extraction, indices were derived from the weighted means of the aspects evaluated by the factor loads of the rotated components matrix. Considering the jth factor, index Ij, defined in the following paragraph, is given by:

$$I_j = \sum_{i=1}^{p^{(j)}} l_{ij} Y_i \Big/ \sum_{i=1}^{p^{(j)}} l_{ij} \qquad (1)$$

where $i = 1; 2; \ldots p^{(j)}; p^{(j)}$ is the number of variables of the j_{th} factor; l_{ij} is the load of the j_{th} factor in the i_{th} variable allocated; and Y_i is the evaluation, graded from 0 to 10, assigned to the i_{th} variable allocated on the j_{th} factor. These indices were used to test the hypotheses. As presented by Equation (1), each index was calculated from its respective factor load values. The collaboration and logistical performance index names are Interpersonal Collaboration Index (ICI), Tactical Collaboration Index (TCI), Strategic Collaboration Index (SCI), Reliability Performance Index (REPI), Transport Index (TRI) and Risk Performance Index (RIPI).

The collaboration indices effect To verify the effect of logistical collaboration on logistical performance, the indices were used in a simple regression analysis (Table 4).

The F-test, significant at 1 percent, and the adjusted R2 suggest that the Interpersonal Collaboration Index (ICI), Tactical Collaboration Index TCI) and Strategic Collaboration Index (SCI) coefficients are positive; thus, greater interpersonal, tactical and strategic collaboration intensity might generate improved logistical performance. For each dependent variable, one independent variable was used (i.e., the other variables were kept constant).

Furthermore, the Mallows' Cp Test was used to compare the precision and bias of the full multiple regression model with the best subsets of predictors. It was confirmed that ICI and SCI are statistically

significant at 1 percent and that the coefficients are positive for each logistical performance index considered by the multiple regression analysis. The TCI was not significant in the multiple regression analysis, suggesting that the interpersonal and strategic collaboration elements exert more impact than the other elements. [41] defend that long-term relationship (i.e., strategic collaboration) can result in improved firm performance. This result was also found by [36] who defended that effective supplier collaboration has a positive impact on firms' competitive performance. On the other hand, the interpersonal relationship is also important to improve logistical performance. For instance, failing to meet the performance standards specified by the agreements, some of which are long-term contracts, such as delays, non-delivery of products or problems with time windows on delivery, may generate fines and a contractual stalling due to a lack of trust and flexibility among the partners. [28] also defended the relationships that include trust, commitment, cooperation and common interests lead to improvements in service levels and cost reductions related to inventory, transportation and order processing.

We highlight the joint analysis of interpersonal and strategic collaboration indices which positively influence the highest-level performance index, i.e. reliability (REPI). In practice, the companies have failed to address the urgent orders and order fill rate during periods of high demand which are rarely fulfilled on time. Our results show companies that have invested in conducting periodic meetings with their partners (i.e. interpersonal collaboration) and that making technical visits (i.e. strategic collaboration) which is fundamental to learning about and understanding the difficulties and logistic strategies of the partner and to share inventory/production information ([42]) have a great chance of increasing delivery performance in terms of on-time deliveries, mistake-free deliveries, urgent deliveries on time, and so forth. Furthermore, risk performance index (RIPI) depends on the degree of the tactical and strategic collaboration and the great commitment among the partners, and the reputation acquired while the trust exists. For instance, not obeying time windows for delivery (causing dock idleness) may generate return of goods; no sharing information of final destination data related to lack of parking and unload areas may be a threat to reliable deliveries; therefore can cause more cargo theft.

Table 4: Estimation of the F and R^2 coefficients in regression analysis

Dependent variables	Independent variables		
	Interpersonal Collaboration Index (ICI)	**Tactical Collaboration Index (TCI)**	**Strategic Collaboration Index (SCI)**
Reliability Performance Index (REPI)	0.686 (0.46; 62.34)	0.588 (0.34; 36.95)	0.538 (0.28; 28.56)
Transport Index (TRI)	0.649 (0.41; 50.95)	0.574 (0.32; 34.37)	0.528 (0.27; 27.00)
Risk Performance Index (RIPI)	0.503 (0.24; 23.74)	0.383 (0.13; 12.00)	0.346 (0.11; 9.50)

Therefore, the results can be important for partners to maintain close relationships to avoid product shortages and thefts, and reduced service levels regarding delivery. A growing supply volume among the partners, increased demand of the service level to the retailer through product diversity, more frequent order fulfilment and other factors that increase the sharing information can lead the companies to become interdependent. This interdependence is the basis provided by trust, reciprocity and flexibility among the partners.

Hence, H1 – An increase in collaboration contributes to a better logistical performance – is confirmed.

Green supply chain requires transporters to undertake a set of sustainable activities conducive to the effective management of their supply chains. The literature review has shown several criteria for supplier selection and the authors suggest that, other than cost, optimized route, perceived quality of transport, delivery, service, selection of sustainable project based on the reduction of package size, vehicle availability and flexibility, and others, are the most important assessment criteria. In order to verify the correlation between the TRI (Transport Index; i.e. vehicle availability, short distance-routing and vehicle external appearance/cleanness) in green supply chain and the sustainable practices, as the supplier selection criteria, the Table 5 shows the main result.

Table 5: TRI and Sustainable practices variables

Variables	Average	Std. Deviation	Correlation
TRI	8.03	1.40	
Sustainable Practices	6.56	2.94	**0.365**

Table 5 shows that the correlation is significant at the 0.01 level and positive; high descriptive statistics values for both variables are also indicated. The result suggests that the partners consider some relevant transport aspects, particularly those related to short distance-routing, vehicle availability and the perceived transport quality described in terms of vehicle external appearance and cleanliness, to sustainable practices. [31] identified that supplier assessment has a positive relationship with quality performance and [23] have identified a positive correlation between the assessment of a supplier's delivery and quality performance. The results suggest partners which have adopted sustainable practices (i.e., measured by air emissions, wastewater disposal, solid waste and energy consumption) have been chosen because of their favorable transport performance.

Therefore, H2 – There is a positive correlation between transport performance indicator and the suppliers selected by sustainable practices – is confirmed.

VI. CONCLUSIONS

From the perspective of the relationship between the supplier and the retailer, considering sustainable criteria in supplier selection has gained more and more attention in practice, this modest research contribute to investigate specific drivers related to collaboration and logistical performance that have not been addressed earlier in the empirical literature, mainly with regard to developing economies.

The factor analysis showed consistency and revealed three different factors which were used to measure collaboration intensity and three factors related to logistical performance measures. It also permitted the creation of indices to assess the impact of logistical collaboration on logistical performance among the 3PL and its partners and to measure the correlation between the transport index with sustainable practices. The results have shown that interpersonal, tactical and strategic collaboration contributes to an improvement in logistic performance concerning reliability, risk and transport. The interpersonal and strategic collaboration indices exert positive influence on reliability which performs the highest-level performance index in terms of on-time delivery, order and delivery without mistakes, urgent deliveries, great lead time to delivery and great deliveries in periods of high demand. Moreover, companies which collaborate with each other, have a good logistical performance in the transport index, tend to be selected by its partners because it adopts sustainable practices. Therefore, this research innovates by making a correlation between transport index and sustainable practices, and indirectly it depends on high collaboration index.

The indices may be useful in developing a stimulating environment for performance management by providing a baseline for comparisons with future partners, assessing the cause and effect of partner relationships, creating a basis for discussing

logistical contingencies and supporting decision-making. Therefore, according to [25], the relationship can create the context for performance measurement.

This research showed that the partners tend to collaborate with each other on relevant aspects of transport. However, it was observed that the respondents of the firms that do not measure CO2 are related to the largest enterprises. Building a green supply chain among partners may thus be a challenge.

Although our research provides suitable statistical results, we might clarify some limitations. The most of these limitations are related to the sample and collection. This research was conducted with a small sample. For example, we cannot split the sample by company categories because it produces smaller sub-samples and makes most of the statistical methods used in the research impracticable. Furthermore, the respondents were asked to provide self-assessments. The responses were collected from the viewpoint of the respondents who works in the companies. To minimize this issue, we instructed the respondents to fill out the survey from the perspective of the organization. Moreover, all scales for measuring the different constructs were previously validated by managers and are largely prevalent in the literature; therefore, the risk of self-assessment bias was decreased. However, three surveys were applied to informants to evaluate different companies. So, the single-method common bias appears to not be an issue for our data.

For future research, a larger number of observations might allow an individual analysis for Carriers, the CPG industry and 3PL, as well as the application of more elaborate statistical techniques, such as structural equation modelling and decision tree making. Also, an in-depth and joint analysis of those three different research fields regarding collaboration, supplier's selection and logistical performance is necessary

Acknowledgements

The authors thank "Fundação de Amparo à Pesquisa do Estado de São Paulo" (FAPESP) (2011/19271-9) for sponsoring this research.

REFERENCES

[1] A. Amindoust, S. Ahmed, A. Saghafinia, and A. Bahreininejad. Sustainable supplier selection: A ranking model based on fuzzy inference system. *Applied Soft Computing*, 12(6), 2012, 1668–1677.

[2] J. S. Armstrong, and T.S. Overton. Estimating non-response bias in mail surveys. *Journal of Marketing Research*, 14(August), 1977, 396–402.

[3] J.F. Audy, N. Lehoux, S. D'Amours, and M. Rönnqvist. A framework for an efficient implementation of logistics collaborations. *International Transactions in Operational Research*, 19(5), 2012, 633–657.

[4] J. B. Barney, and M. Hansen. Trustworthiness and Competitive Advantage. *Strategic Management Journal*, 15(S1), 1994, 175–190.

[5] D. J. Bowersox. The strategic benefits of logistics alliances. *Harvard Business Review*, July-August, 1990, 36–45.

[6] G. H. Brundtland. *Our Common Future/World Commission on Environment and Development* (Oxford University Press, 1987).

[7] G. Chow. Logistics performance: definition and measurement. *International Journal of Physical Distribution & Logistics Management*, 24(1), 1994, 17–28.

[8] G. A. Churchill, and D. Iacobucci. *Marketing research: methodological foundations* (Cengage Learning, 2009).

[9] C.J. Corbett, and R.D. Klassen. Extending the horizons: Environmental excellence as key to improving operations. *Manufacturing and Service Operations Management*, 8(1), 2006, 5–22.

[10] F. T. Chan, and N. Kumar. Global supplier development considering risk factors using fuzzy extended AHP-based approach. *Omega*, 35(4), 2007, 417-431.

[11] Ellram, L.M. The Supplier Selection Decision in Strategic Partnerships. *International Journal of Purchasing and Materials Management*, 26(4), 1990, 8-14.

[12] T. Eltayeb, S. Zailani, and T. Ramayah. Green supply chain initiatives among certified companies in Malaysia and environmental sustainability: Investigating the outcomes. Resources. *Conservation and Recycling*, 55(5), 2011, 495–506.

[13] C. Emberson, and J. Storey. Buyer–supplier collaborative relationships: Beyond the normative accounts. *Journal of Purchasing and Supply Management*, 12(5), 2006, 236–245.

[14] L. Enarsson. Evaluation of suppliers: how to consider the environment. *International Journal of Physical Distribution & Logistics Management*, 28(1), 1998, 5–17.

[15] M. Forman, and M.S. Jørgensen. Organising Environmental Supply Chain Management: Experience from a Sector with Frequent Product Shifts and Complex Product Chains: The Case of the Danish Textile Sector. *Greener Management International*, 1(5), 2004, 43–62.

[16] C. Forza. Survey research in operations management: a process-based perspective.

International Journal of Operations & Production Management, 22(2), 2002, 152–194.

[17] K. Goffin, F. Lemke, and M. Szwejczewski. An exploratory study of "close" supplier–manufacturer relationships. *Journal of Operations Management*, 24(2), 2006, 189–209.

[18] K. Govindan, S. Rajendran, J. Sarkis, and P. Murugesan. Multi criteria decision making approaches for green supplier evaluation and selection: a literature review. *Journal of Cleaner Production*, 2013, in press.

[19] J. Hall. Environmental supply chain dynamics. *Journal of Cleaner Production*, 8(6), 2000, 455–471.

[20] R. Handfield, S.V. Walton, R. Sroufe, and S.A. Melnyk. Applying environmental criteria to supplier assessment: A study in the application of the Analytical Hierarchy Process. *European Journal of Operational Research*, 141(1), 2002, 70-87.

[21] W.Ho, X. Xu, and P.K. Dey. Multi-criteria decision making approaches for supplier evaluation and selection: A literature review. *European Journal of Operational Research*, 202(1), 2010, 16-24.

[22] D. Kannan, A.B.L.D.S. Jabbour, and Jabbour, C.J.C. Selecting green suppliers based on GSCM practices: Using fuzzy TOPSIS applied to a Brazilian electronics company. *European Journal of Operational Research*, 233(2), 2014, 432-447.

[23] V. R. Kannan, and K.C. Tan. Supplier selection and assessment: their impact on business performance. *Journal of Supply Chain Management*, 38(3), 2002, 11-21.

[24] D.M. Lambert, and T.L. Pohlen. Supply chain metrics. *International Journal of Logistics Management*, 12(1), 2001, 1-19.

[25] M.J. Lebas. Performance measurement and performance management. *International Journal of Production Economics*, 41(1), 1995, 23-35.

[26] S.Y. Lee. Drivers for the participation of small and medium-sized suppliers in green supply chain initiatives. *Supply Chain Management: An International Journal*, 13(3), 2008, 185–198.

[27] M. Lindholm. Urban freight transport from a local authority perspective – a literature review. *European Transport*, 3(54), 2013,1–37.

[28] J.T. Mentzer, J.H. Foggin, and S.L. Golicic. Collaboration: the enablers, impediments, and benefits. *Supply Chain Management Review*, 4 (4), 2000, 52-57.

[29] A. Neely, M. Gregory, and K. Platts. Performance measurement system design: a literature review and research agenda. *International Journal of Operations & Production Management*, 15(4), 1995, 80-116.

[30] D. Prajogo, and J. Olhager. Supply chain integration and performance: The effects of long-term relationships, information technology and sharing, and logistics integration. *International Journal of Production Economics*, 135(1), 2012, 514-522.

[31] D. Prajogo, M. Chowdhury, A.C. Yeung, and T.C.E. Cheng. The relationship between supplier management and firm's operational performance: a multi-dimensional perspective. *International Journal of Production Economics*, 136(1), 2012, 123-130.

[32] J. Rodrigues, T. Domingos, S. Giljum, and F. Schneider. Designing an indicator of environmental responsibility. *Ecological Economics*, 59(3), 2006, 256-266.

[33] J. Sarkis, L.M Meade, and A.R. Presley. Incorporating sustainability into contractor evaluation and team formation in the built environment. *Journal of Cleaner Production*, 1(31), 2012, 40-53.

[34] J. Sarkis, and S. Talluri, A model for strategic supplier selection. *Journal of Supply Chain Management*, 38(1), 2002, 18-28.

[35] M.D.A. Serna, C.A.S. Uran, and K.C.A. Uribe. Collaborative autonomous systems in models of urban logistics. *Dyna*, 79(172), 2012, 171-179.

[36] Singh, P. J., Power, D. (2009). The nature and effectiveness of collaboration between firms, their customers and suppliers: a supply chain perspective. *Supply Chain Management: An International Journal*, 14(3), 189–200.

[37] T.P. Stank, S.B. Keller, and P.J. Daugherty. Supply chain collaboration and logistical service performance. *Journal of Business logistics*, 22(1), 2001, 29-48.

[38] G. Stefansson. Collaborative logistics management and the role of third-party service providers. *International Journal of Physical Distribution & Logistics Management*, 36(2), 2006. 76-92.

[39] T. Van der Vaart, and D.P. Van Donk, A critical review of survey-based research in supply chain integration. *International Journal of Production Economics*, 111(1), 2008, 42-55.

[40] A. Vereecke, and S. Muylle. Performance improvement through supply chain collaboration in Europe. *International Journal of Operations & Production Management*, 26(11), 2006, 1176-1198.
[41] S.K. Vickery, J. Jayaram, C. Droge, and R. Calantone. The effects of an integrative supply chain strategy on customer service and financial performance: an analysis of direct versus indirect relationships. *Journal of Operations Management*, 21(5), 2003, 523–539.
[42] Vieira, J., Yoshizaki, H. and Ho, L.. Collaboration intensity in the Brazilian supermarket retail chain. *Supply Chain Management: An International Journal*, 14(1), pp.11-21, 2009.
[43] Q. Zhu, Y. Dou, and J. Sarkis. A portfolio-based analysis for green supplier management using the analytical network process. *Supply Chain Management: An International Journal*, 15(4), 2010, 306-319.
[44] Q. Zhu, and J. Sarkis. Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. *Journal of Operations Management*, 22(3), 2004, 265-289.