Supply Chain Collaboration: Antecedents and Consequences

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Abstract: In the past twenty years, firms have strived to achieve greater supply chain collaboration to leverage the resources and knowledge of their suppliers and customers. The objective of the study is to uncover the nature of supply chain collaboration and explore its antecedents and consequences. Reliable and valid instruments of these constructs were developed through rigorous empirical analysis including structured interviews, Q-sort, and a large-scale study. Data were collected through a Web survey of U.S. manufacturing firms in various industries. The statistical methods used include confirmatory factor analysis and structural equation modeling (i.e., LISREL). The results indicate that IOS appropriation supports supply chain collaboration, which in turn improves collaborative advantage.

Keywords: Supply Chain Collaboration, IOS Appropriation, Collaborative Advantage, Survey Research

I. Introduction

The competition today is no longer between individual firms but between supply chains or supply networks [5]. To survive and thrive in this emerging competitive environment, firms strive to achieve greater supply chain collaboration to leverage the resources and knowledge of their suppliers and customers [4] [5] [6], which may be the ultimate core capability.

Supply chain collaboration means two or more autonomous firms working jointly to plan and execute supply chain operations [10]. It can deliver substantial benefits and advantages to its partners. Collaborative relationships can help firms share risks, access complementary resources, reduce transaction costs and enhance productivity, and enhance profit performance and competitive advantage over time.

Internet based information and communication technologies (ICT), particularly inter organizational systems (IOS), further extend firms' opportunities to strengthen their supply chain partnerships and share real-time information to optimize their operations [5]. Using IOS, supply chain partners develop close relationships in a chain structure, which enables them to access each other's privileged data and information. Such electronic hierarchies allow firms to achieve the effect of vertical integration without ownership through the use of IOS to tie-in partners and lock out competitors, and thus achieve sustainable competitive advantage.

Despite the popularity and benefits of supply chain collaboration, many partner relationships fall short of meeting the participants' expectations. Few firms have truly capitalized on the potential of supply chain collaboration [8]. Supply chain collaboration seems to have great potential, but further investigation is needed to recognize its value.

First, although the advantages of supply chain collaboration are widely acknowledged in the literature, its exact nature and attributes are not well comprehended. Sheu et al. [9] point out that the literature on supply chain collaboration is fragmented in that different disciplines often focus on only a small number of different factors. Research in marketing and management focuses on factors such as commitment, studies in operations management concentrate on factors such as information sharing and inventory systems, and information systems researchers focus on IT capabilities. Fragmentation has prevented the rapid advancement of knowledge.

Second, in characterizing and conceptualizing supply chain collaboration, researchers focus more on process integration (e.g., goal congruence, decision synchronization, incentive alignment, and resource sharing) and less on collaborative communication and joint knowledge creation components. Miscommunication, which causes conflicts and misunderstanding between supply chain partners, is recognized as the reason for many collaboration failures.

Third, in investigating the consequences of supply chain collaboration, existing literature has ignored the collaborative advantage achieved through collaboration. Collaboration between supply chain partners is not merely pure transactions, but leverages information sharing and market knowledge creation for sustainable competitive advantage [8].

The objective of the study is to uncover the nature and characteristics of supply chain collaboration and explore its antecedent and consequences. By pooling an extensive set of factors, the research extends our understanding of the attributes of supply chain collaboration, IOS appropriation, and collaborative advantage. Through a large-scale Web survey with manufacturers across the US, the research also intends to develop reliable and valid instruments and to empirically test the relationships among IOS appropriation, supply chain collaboration, and collaborative advantage.
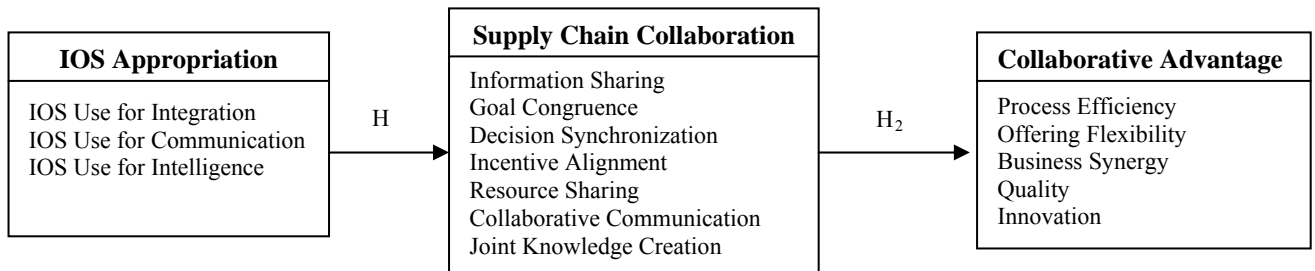
II. Conceptual Development

Figure 1: Supply Chain Collaboration: Antecedent and Consequence

By collaborating, supply chain partners can work as if they were a part of a single enterprise (Lambert and Christopher, 2000). Such collaboration is facilitated by the use of IOS, and increases collaborative advantage. These relationships are captured in a framework as shown in Figure 1.

IOS Appropriation
IOS appropriation is defined as patterns, modes, or fashions of IOS use. It includes the following three components: IOS Use for Integration, IOS Use for Communication, and IOS Use for Intelligence.

Supply chain collaboration
It includes the following seven components: Information Sharing, Goal Congruence, Decision Synchronization, Incentive Alignment, Resource Sharing, Collaborative Communication, and Joint Knowledge Creation.

Collaborative Advantage
Collaborative advantage refers to strategic benefits gained over competitors in the marketplace through supply chain partnering. Collaborative advantage relates to the desired synergistic outcome of collaborative activity that could not have been achieved by any firm acting alone. It includes process efficiency, offering flexibility, business synergy, quality, and innovation.

Hypotheses Development

Hypothesis 1: IOS appropriation has a significant positive effect on supply chain collaboration.
Hypothesis 2: Supply chain collaboration has a significant positive effect on collaborative advantage.

III. Instrument Development

The development of instruments for IOS appropriation, supply chain collaboration, and collaborative advantage was carried out in three steps: (1) item generation, (2) structured interview and Q-sort, and (3) large-scale analysis. First, to ensure the content validity of the constructs, an extensive literature review was conducted to define each construct and

generate the initial items for measuring the constructs. Then, a structured interview and Q-sort were conducted to provide a preliminary assessment of the reliability and validity of the scales. The third step was a large-scale survey to validate the instruments.

Item Generation
The objective of item generation is to achieve the content validity of constructs by reviewing literature and consulting with academic and industrial experts. The measurement items for a scale should cover the content domain of a construct [1]. To generate measurement items for each construct, prior research was extensively reviewed and an initial list of potential items was compiled. A five-point Likert scale was used to indicate the extent to which managers agree or disagree with each statement where 1=strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

Structured Interview and Q-Sort
After the measurement items were created, the common pool of items were reviewed and evaluated by practitioners from four different manufacturing firms to pre-assess the reliability and validity of the scales. First, structured interviews were conducted to check the relevance and clarity of each sub-construct's definition and the wording of question items. Then, interviewees were asked to sort out the questionnaire items into corresponding sub-constructs. Based on the feedback from the experts, redundant and ambiguous items were eliminated or modified. New items were added when necessary. After two rounds of Q-sort, items were distributed to six academicians who reviewed each item and indicated to keep, drop, modify, or add items to the constructs. Based on the feedback from the reviewers, items were further modified. Overall, 77 questionnaire items were sent out for a large-scale survey.

Sampling Design and Large-Scale Data Collection
The sample respondents were expected to have knowledge or experience in supply chain management. The target respondents were CEOs, presidents, vice presidents, directors, or managers in the manufacturing firms across the

U.S. The sample respondents were expected to cover the following seven SIC codes: Furniture and Fixtures (SIC 25), Rubber and Plastic Products (SIC 30), Fabricated Metal Products (SIC 34), Industrial Machinery and Equipment (SIC 35), Electric and Electronic Equipment (SIC 36), Transportation Equipment (SIC 37), and Instruments and Related Products (SIC 38).

An email list of 5,000 target respondents were purchased from Council of Supply Chain Management Professionals (CSCMP), a prestigious association of professionals in the area of supply chain management, and lead411.com, a professional list company which is specialized at providing executive level email lists. A Web survey was conducted to reach as many respondents as possible and retrieve as much information as possible in short time. Excluding multiple names from the same organization, undelivered emails, and returned emails saying that target respondents were no longer with the company, the actual mailing list contained 3,538 names.

To improve the response rate, three waves of emails were sent once a week. Out of the 227 responses received (16 incomplete), 211 are usable resulting in a response rate of 6.0%. A chi-square test is conducted to check non-response bias. The results show that there is no significant difference between the first-wave and second/third-wave respondents by all three categories (i.e., SIC code, firm size, and job title) at the level of 0.1. It exhibits that received questionnaires from respondents represent an unbiased sample.

Large-Scale Data Analysis Methods

Using confirmatory factor analysis with LISREL, steps were undertaken to check (1) unidimensionality and convergent validity, (2) reliability, (3) discriminant validity, and (4) second-order construct validity. The assessment was conducted for each construct in one first-order correlated model so related multi-items measures are grouped together. Iterative modifications were undertaken by dropping items with loadings less than 0.7 and also items with high correlated errors thus improving the model fit to acceptable levels [2] [3]. In all cases where refinement was indicated, items were deleted if such action was theoretically sound and the deletions were done one at each step [2]. Model modifications were continued until all parameter estimates and model fits were judged to be satisfactory.

Unidimensionality is assessed by the fit indices and convergent validity is assessed by the significance of t-values of each measurement indicator. The overall model fit can be tested using the comparative fit index (CFI), non-normed fit index (NNFI), root mean square error of approximation (RMSEA), and normed chi-square (i.e., $\chi 2$ per degree of freedom) [2] [3]. Values of CFI and NNFI between 0.80 and 0.89 represent a reasonable fit and scores of 0.90 or higher are evidence of good fit. Values of RMSEA less than 0.08 are acceptable [2]. The normed chi-square ($\chi 2$ divided by degrees of freedom) estimates the relative efficiency of competing models. For this statistic, a value less than 5.0 is preferred.

Following Hair et al. [2], the composite reliability (ρc) and the average variance extracted (AVE) of multiple indicators of a construct can be used to assess reliability of a construct. When AVE is greater than 50% and ρc is greater than 0.70, it implies that the variance by the trait is more than that by error components [2].

To check the discriminant validity, a pair-wise comparison was performed by comparing a model with correlation constrained to one with an unconstrained model. A difference between the $\chi 2$ values of the two models that is significant at p<0.05 level would indicate support for the discriminant validity criterion.

An important aspect of construct validity is the validation of second-order constructs. T coefficient was used to test whether a second-order construct exists accounting for the variations in its sub-constructs. T coefficient is calculated as the ratio of the chi-square of the first-order model to the chi-square of the second-order model and a T coefficient of higher than 0.80 indicates the existence of a second-order construct.

Finally, a LISREL model is run to test the hypotheses developed in the framework.

IV. Results

Large-Scale Measurement Results

The construct of IOS appropriation was initially represented by three dimensions and 15 items. An all-factor correlated LISREL measurement model was specified for each construct. Following Hair et al. [2], iterative modifications were made by examining modification indices, correlated errors, and loadings to improve key model fit statistics.

The final model fit indices of CFI, NNFI, RMSEA, and normed χ^2 for each dimension meet the recommended criteria, demonstrating good unidimensionality. The item loadings for each factor are greater than 0.70 and significant at p<0.01 based on t-values. All dimensions exhibit good convergent validity.

The estimates of AVEs for the seven factors are 0.68, 0.64, and 0.75 respectively, greater than the critical value of 0.50. The composite reliabilities (ρ_c's) for the seven factors are 0.90, 0.88, and 0.92 respectively, above the critical value of 0.70. The results of the AVEs and ρ_c's provide evidence of good reliability for each factor.

Validation of Second-Order Constructs

The second-order model explains the co-variations among first-order factors in a more parsimonious way. However, the variations shared by the first-order factors cannot be totally explained by the single second-order factor, and thus the fit indices of the higher-order model can never be better than the corresponding first-order model. The first-order model provides a target fit for higher-order models. The

efficacy of second-order models can be assessed by examining the target (T) coefficient [7]. The T coefficient 0.80 to 1.00 indicates the existence of a second-order construct.

The T-coefficients for IOS appropriation, supply chain collaboration, and collaborative advantage are 0.987, 0.974, and 0.925 respectively, suggesting that the second-order models should be accepted as more accurate representation of model structure over the corresponding first-order model because they represent more parsimonious explanation of observed covariance. The results support the second-order constructs proposed in the conceptual development section.

Hypotheses Testing Results

To test the hypotheses proposed in the framework, structural equation modeling (LISREL) was used to assess the model fit with the data. The summed item scores for each dimension are used as indicators to measure of the three constructs.

The path diagram and the loadings for the LISREL model are shown in Figure 2. In terms of overall fit, chi-square statistic is 281.97 with df = 88 and the ratio of chi-square to degrees of freedom is 3.20, which indicates a good fit. The model fit indices NNFI = 0.90, CFI = 0.92 are very good. RMSEA = 0.10 is a bit above 0.08.

The results in Figure 2 support Hypotheses 1 and 2. The LISREL path coefficients are respectively 0.92 (t = 13.54) and 0.64 (t = 8.96), which are statistically significant at the level of 0.01. This supports the claim that IOS appropriation has significant, positive, and direct impacts on supply chain collaboration, which in turn has significant, positive, and direct impact on collaborative advantage.

It is also important to note that IOS appropriation has a positive indirect impact on collaborative advantage (path coefficient = 0.59, t = 8.45) along the path of supply chain collaboration. Therefore, better use of IOS among supply chain partners indirectly helps partners to achieve synergies and create superior performance.
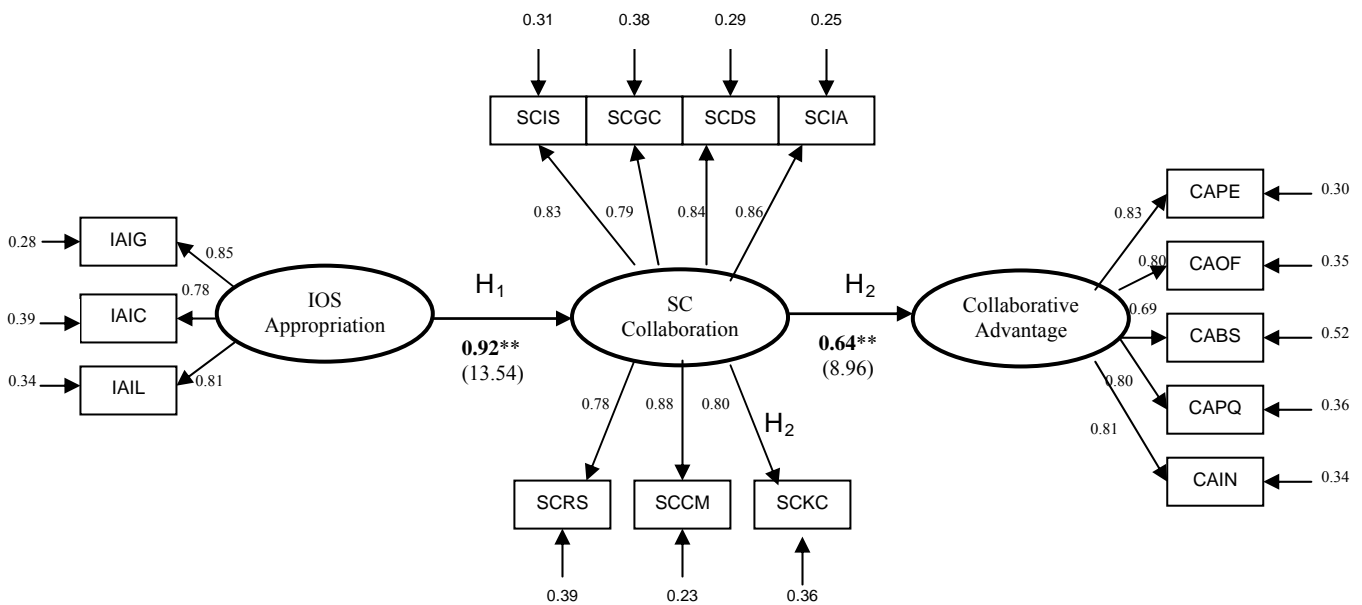
Note: Chi-Square = 281.97; df =88; Normed χ^2 =3.20; RMSEA = 0.10; CFI=0.92; NNFI=0.90.

Figure 2: Hypotheses Test Using Structural Equation Model (Path & Measurement)

V. Discussion, Implications, and Limitations

The study has developed valid and reliable instruments for IOS appropriation, supply chain collaboration and collaborative advantage. All the scales have been tested through rigorous statistical methodologies including Q-sort method, confirmatory factor analysis, reliability, and the validation of second-order construct. All the scales are shown to meet the requirements for reliability and validity and thus can be used in future research. The accurate

definitions and measures of these constructs has provided a rich and structured understanding of what occurs in a supply chain or network. They also facilitate empirical research efforts because the relationships among constructs can be better captured with better definitions and measures.

The results empirically confirm that IOS appropriation supports the supply chain collaboration (H1) and well executed supply chain collaboration directly improves collaborative advantage (H2).

In addition to the theoretical contributions of the study, there

are practical implications that can be inferred. The definition and measures of IOS appropriation, supply chain collaboration and collaborative advantages can help managers to define specific actions to be taken collaboratively to improve shared supply chain processes that benefit all members. The definition and measurements can serve as a powerful tool for managers to form effective collaborative relationships.

While the research has made significant contributions to research and practice, there are limitations that need to be considered when interpreting the study findings. Because of the limited number of observations (211), the revalidation of constructs was not carried out in this research. This needs to be addressed in the future research.

Future research should apply multiple methods to obtain data. The use of a single respondent to represent what are supposed to supply chain wide variables may generate some inaccuracy and more than the usual amount of random error. Future research should seek to utilize multiple respondents from each participating organization as an effort to enhance reliability of research findings. More insights will be gained by collecting information from both sides of the manufacturer-supplier dyad rather than just from one organization.

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