The Effects of Supply Chain Measurement Systems on Supply Chain Integration

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ABSTRACT

When firms practice Supply Chain Integration it leads to improved supply chain performance. Those firms that are able to achieve integration so do through robust measurement systems, which one study shows also leads to sustainability of integration over the long-term. The purpose of this paper is to show that robust measurement systems that evaluate supply chain-wide performance, leads to long-term integration. In doing so, we show critical links between supply chain measurement capability and supply chain integration. The model is tested through empirical research involving 102 firms. The results show that supply integration can be sustained by establishing a supply chain wide measurement system.

Key Words: Supply Chain Integration; Supply Chain Evaluation System; Sustainability, Theory Building

INTRODUCTION

It is generally accepted in the literature that successful manufacturing firms no longer compete head-to-head with other firms, but instead, they compete supply chain -to- supply chain. This means that firms rely on the complementation between their own internal competencies and those of their supply chain partners to achieve competitive advantage. To achieve complementary competencies among independently owned firms, a relatively new form of organizational governance, called Supply Chain Integration (SCI), is preferred over more
traditional forms such as vertical integration or market-orientation. The advantage of developing SCI capability is that it achieves the collaboration and communication capabilities of vertically integrated firms while maintaining the flexibility and responsiveness capabilities of market-oriented firms. This allows firms with SCI capabilities to compete in new ways that help them, and their partner firms, achieve superior performance. Growing evidence suggests that the higher the degree of SCI capabilities achieved, the greater the potential benefits. Some studies show that SCI capabilities result in cost reductions, improvements in inventory, customer service, new product development, information and material flows, and financial performance for the focal firm (Stevens, 1990; Lee et al., 1997; Narasimhan and Jayaram, 1998; Johnson, 1999; Frohlich and Westbrook, 2001; Rosenzweig et al., 2003; Vickery et al., 2003; Droge et al., 2004; Bagchi et al., 2005). However, these studies examined how SCI affects the performance of an individual focal firm rather than the performance of the supply chain as a whole.

Despite the aforementioned studies, which show a positive relationship between SCI and focal firm performance, others show that the positive relationship diminishes over time. Stated differently, firms that initially achieved SCI were unable to sustain it, and its benefits, in the long run (e.g., Boddy et al., 1998; Spekman et al., 1998; Holmberg, 2000; Lapide, 2000; Vinas, 2001; Lambert and Pohlen, 2001; KPMG Consultants report, 2003; Upstate South Carolina Supply Chain Consortium survey report, 2003; Moberg and Speh, 2003; Lee, 2004). The capabilities appear to have deteriorated over time - leading to a tremendous waste of financial and temporal resources and consequently, harming the ability of the supply chain to stay competitive. This finding is counter-intuitive in that supply chains achieving superior performance through SCI capabilities should be able to maintain the capabilities over time.

The purpose of this study is to provide theoretical and empirical support for explaining why supply chain partners fail to sustain SCI in the long term and thus fail to maintain superior supply chain performance. In doing so, we suggest how supply chain partners can sustain SCI and its associated benefits.

LITERATURE REVIEW
The literature suggests that superior business performance is achieved through competitive advantage by developing business capabilities that provide value-added activities to end-users in unique ways or at lower prices than competitors (Porter, 1991). Providing value-added activities
in unique and low-cost ways require anticipating customer demand and responding to changes in the demand faster than competitors (Stalk et al., 1992). Independent firms can leverage each others’ capabilities to achieve competitive advantage for the entire supply chain. The literature refers to the leverage of capabilities in a supply chain as an outcome of SCI (Geoffrion and Powers, 1995).

To explain how companies create capabilities, the Resource-Based View (RBV) theory says that firms must invest resources in improving business processes (Stank et al., 2005). These include, but are not limited to, customer focus, time management, integration, information exchange, demand management, new product development, and evaluation capabilities.

**Supply Chain Evaluation Capabilities (SCPM)**

In addressing the importance of evaluation capabilities, Lambert and Pohlen (2001), argue that they are essential to supporting and sustaining SCI capabilities. They stress the importance of developing supply chain evaluation system capabilities, which they refer to as Supply Chain Performance Measurement Systems (SCPM), for sustaining SCI. In academia, SCPM is generally described as an evaluation system designed to measure system-wide performance of all firms in a supply chain. It differs from performance metrics designed to measure specific functions or activities of individual firms (Holmberg, 2000; Lambert and Pohlen, 2001). The need for SCPM is explained by Transaction Cost Economics theory (TCE). Two important key tenets of TCE (Williamson, 1975; 1985) are “Opportunism” and “Transaction risk”. Opportunism arises when human actors in the exchange relationship are guided by considerations of self-interest with guile. In a supply chain context, there are several opportunities for “opportunistic” behavior where one player tries to get the maximum benefits at the expense of other players. A transaction’s risk includes the risk that other parties in the transaction will shirk their agreed upon responsibilities. In order to curb opportunistic behavior and minimize transaction risks, SCPM can monitor each player in the supply chain.

In developing SCPM, some studies emphasize the importance of functional-based measures at the firm level, such as operational functions (e.g., product quality, number of on-time deliveries, etc.) and financial functions (e.g., measures based on cost) (e.g. Beamon, 1998; Brewer and Speh, 2000; Gunasekaran et al., 2001; Gunasekaran et al., 2004). In deference to the functional-based measures, Bullinger et al. (2002) and Chan and Qi (2003) suggest a greater
emphasis should be placed on process-based metrics at the firm level. However, other studies stress the importance of process-based measures beyond the firm level, to include multiple firms in a supply chain (e.g. Bechtel and Jayaram, 1997; Holmberg, 2000; Lambert and Pohlen, 2001; Morgan, 2004). They suggest that performance evaluation beyond the firm-level is important because improvement in individual firm performance (metrics) does not necessarily lead to improvement for the whole supply chain. For example, one firm may compete on flexibility – measuring success by how well it responds to changing customer requirements – while another firm may compete primarily on efficiency – measuring success by the cost of its operations. This difference in competitive priorities can lead to inter-firm conflict that harms performance. Addressing this conflict, the frameworks of Fisher (1997) and Lee (2002) classify supply chains based on the extent of demand and supply uncertainties faced – i.e. functional, innovative, agile, and risk hedging. Lambert and Pohlen (2001) argue that supply chains warrant a unique set of performance goals and measures because the characteristics and emphasis of each are substantially different. They assert that “the goal should not be to identify specific metrics, but to provide a framework that allows management to develop the best performance measures for their situation”. They refer to this framework as a SCPM system. They argue that failure to develop a SCPM system leads to misaligned performance measures that do not relate to the strategic non-financial performance and effectiveness of the system, ill-defined or inappropriate performance metrics used to guide decisions, and lack of accountability throughout the system.

One method of developing performance evaluation system was based on the SCOR model (supply chain operations reference) (Stewart, 1997). This model, developed by the Supply Chain Council, is the first cross-industry framework for evaluating supply chain performance and management. The SCOR model features four levels of supply-chain management:

a) Level 1 provides a broad definition of the plan, source, make, deliver process types, and is the point at which a company establishes its supply chain competitive objectives.

b) Level 2 defines 26 core process categories that are possible components of a supply chain system. A company can configure both its actual and ideal supply chain by selecting from these core processes.

c) Level 3 provides a company with the information it needs to plan and set goals successfully for its supply-chain improvements through detailed process element information for each level 2
category. Planning elements include process element definitions, diagnostic metrics, benchmarks, best practices, and system software capabilities to enable best practices.

d) Level 4 focuses on implementation, when companies put specific supply-chain improvements into play. Since changes at level 4 are unique to each company, the specific elements of the level are not defined within the industry-standard model.

While valuable, the SCOR model is tactically-focused, and as such lacks the components necessary to guide the strategic development of effective SCPM. Strategic development ensures that individual firm-level metrics are aligned with the goals of the whole supply chain (e.g. Holmberg, 2000; Lambert and Pohlen, 2001). This alignment is important because the “goal theory” (Linderman et al., 2003) says that an organization’s goals drive its behavior. Extending goal theory to the supply chain suggests that supply chain goals drive the behavior of supply chain managers. This underscores the importance of companies to develop capabilities in monitoring internal process goals as well as external process goals with suppliers and customers.

**Defining Supply Chain Evaluation Capability (SCPM)**

To extend the definition of Lambert and Pohlen (2001) to incorporate the conclusions of Eccles and Pyburn, 1992; Holmberg, 2000; Stank et al., 2005), we define SCPM as: *an evaluation system that provides a formal definition of the supply chain performance model based on mutually agreed upon goals, measures, measurement methods that specify procedures, responsibilities and accountability of internal business processes, external supply chain participants, and the monitoring of the system by supply chain participants.*

Note that the above definition of SCPM can be used to guide practitioners in developing evaluation systems that monitor the entire supply chain. It covers the main factors of – goals, measures, and methods. However, to develop capabilities in goals, measures, and methods requires the allocation of resources. Next, we discuss the resources and capabilities necessary to develop SCPM.

**Capabilities in Monitoring External Processes**

To develop ‘Capabilities in Monitoring External Processes’ requires the allocation of resources to the management, technology, software, and personnel used to develop a) compatible goals, b) the proper metrics to measure the goals, and c) the methods to gather, analyze, and interpret the
data. In other words, this involves the effective allocation of resources in an inter-organizational system that facilitates measuring the performance of the external supply chain members to meet supply chain goals rather than local goals. However, it is important to note that external, system-wide performance targets must be broken-down into meaningful and compatible internal, firm-level expectations and measured as such. The experience of Alcatel serves to illustrate how external monitoring may be achieved by establishing a supply chain level performance measurement system. Alcatel embarked on project ‘Titan’ with its key supply chain partners in the areas of order management, inventory management, capacity collaboration and forecasting collaboration. The players collectively identified a common set of supply chain goals (better on time delivery performance, new product development time reduction, less inventory in terms of days of supply, and improved forecast accuracy). They achieved these goals by deploying an external supply chain performance measurement system aligned to these goals. This helped Alcatel to integrate with its key partners (Supply Chain Council conference, 2001).

Constant monitoring and control of external processes is needed for an effective evaluation system (Korpela et al., 2001). The Systems Theory literature says that this is best achieved by means of a closed-loop system – one that provides regular, timely feedback on performance to all participants that regulate the system (Korpela et al., 2001). The closed loop systems approach is shown in Figure 1. Monitoring and control helps in improving supply chain performance where the partners continue to derive strategic benefits.

**Figure 1. A closed-loop supply chain**

Monitoring and control of a supply chain is a dynamic process that involves providing regular and timely feedback to all partners. This means that the contribution of each partner is tracked and compared to standards. Deviations are noted and corrective actions are undertaken. Any problems arising due to misalignment of performance measurement systems among the supply chain partners are identified and resolved (Korpela et al., 2001). Several companies, such as Adaptec Inc, Borden Chemicals Inc, Alcatel, Ingram Micro Inc, Hewlett Packard, and 3M, monitor and control the joint performance of partners. AT&T Wireless supply chain, for example, monitored the joint performance of supply chain participants and embarked on
improving the following performance areas: system delivery performance, inventory held in the system, and cash to cash conversion time (Supply Chain Council Conference, 2001).

To deploy an external monitoring system, the literature identifies three major options. 1) Fransoo et al. (2001) suggest using a central supply chain manager who oversees monitoring and control. 2) Cachon and Lariviire (2001) suggest that contracts can coordinate the relationships and expectations among partners. 3) Lee (2000) suggests that a powerful partner can also play the role of supply chain monitor. Despite their apparent differences on the “how,” all agree on “what” should be monitored and controlled.

Based on these studies, Capabilities in Monitoring External Processes is defined as, a firm’s ability to effectively set congruent goals that do not conflict with other supply chain members, and measure, monitor and control them across the supply chain.

This is important because monitoring and control helps in improving supply chain performance where the partners continue to derive strategic benefits. As partners realize the benefits of integration, their dependence and commitment to tighter supply chain relationships increases, thus helping to sustaining supply chain integration. From relationship marketing perspective, “dependence” is the recognition by both partners in an exchange relationship that the relationship provides greater benefits than what either partner could attain alone (Dwyer et al., 1987; Mohr and Spekman, 1994). Commitment to the SCPM is described as an "implicit or explicit pledge of relational continuity between exchange partners" (Dwyer et al., 1987). Commitment ensures that supply chain partners 1) work at preserving relationship investments by cooperating with external partners; and 2) resist attractive short term alternatives in favor of the expected long-tern benefits of staying with existing partners. Thus, both dependence and long term commitment to SCPM help partners in sustaining SCI.

Capabilities in Monitoring Internal Processes
By ‘Capabilities in Monitoring Internal Processes’ we refer to the resources allocated to monitor internal, firm-level targets. While the measurement of internal processes may involve metrics that do not apply externally to other supply chain members, they should not promote process goals that are counter to supply chain goals. Constant monitoring and control of internal processes is needed for an effective evaluation system that promotes internal integration.
Internal monitoring and control helps in improving performance where the firm continues to derive benefits.

Monitoring and control is a dynamic process that involves providing regular and timely feedback to all functions. This means that the contribution of each function is tracked and compared to standards. Deviations are noted and corrective actions are undertaken. Any problems arising due to misalignment of performance measurement systems are identified and resolved (Korpela et al., 2001). Based on the literature, Capabilities in Monitoring Internal Processes is defined as, *a firm’s ability to effectively set congruent goals that do not conflict with supply chain goals, and measure, monitor and control them across internal business processes.*

Internal monitoring and control helps to prevent the misalignment between internal and external goals thus contributing to supply chain performance where the partners continue to derive strategic benefits.

**Supply Chain Integration Capabilities (SCI)**

Stank et al. (2005), show that SCI capability is created through the development of capabilities in both communication and collaboration. They argue that SCI capabilities are driven by the integration of internal functions along with the external integration of downstream (customers) and upstream (suppliers) supply chain partners. Their conclusions serve to reconcile the studies by Armistead and Mapes (1993), and Pagell (2004) that emphasize the importance of internal integration, and those of Stevens (1990), Anderson and Lee (2000), and Aryee et al. (2005), that emphasize the importance of external integration, i.e. that true and full SCI is achieved only when communication and collaboration among multiple partners occur. The essence of their argument is that firms go through three phases of integration – starting with, a) optimization within a business function, followed by b) internal integration between business functions, and c) culminating in external synchronization and collaboration across supply chain participants (business units with their suppliers and customers). These studies suggest that capabilities and benefits increase as firms’ progress from the optimization stage to the external collaboration (synchronization and coordination) stage. Other studies, while they differ in semantics, generally follow a similar three to five stage model. (e.g. Narasimhan and Jayaram, 1998; Frohlich and Westbrook, 2001; Rozenweig et al., 2003; and Vickery et al., 2003). For example, Frohlich and Westbrook (2001) define SCI as a function of direction and degree, where the
directional aspect (called the arc of integration) captures whether integration exists within the organization and with supplier and/or customers. Accordingly, they define five arcs of integration ranging from an “inward-facing internal” focus to an “outward-facing supply chain” focus. The degree aspect captures the extent to which organizations collaborate (i.e. use the information to synchronize and coordinate their activities). It is clear from the literature that SCI is a function of both direction and degree of communication – which we refer to in our model as ‘Capabilities in Communication’ - and collaboration – which we refer to as ‘Capabilities in Collaboration’.

Capabilities in Communication
The resources allocated to developing Capabilities in Communication involve investment in the technology infrastructure and assigning the personnel to facilitate information-sharing internally (among functions) and externally (with customers and suppliers). Adapted from Stank et al. (2005), Capabilities in Communication are defined as: the degree to which a firm has developed the ability (e.g. the individual contacts, hardware, software, and connectivity technology – e.g. Internet access) to communicate effectively within internal functions, and with external customers and suppliers.

Capabilities in Collaboration
An organization is “a system of interrelated but distinct subsystems (departments or business units) with each subsystem performing a portion of the organizational task, and efforts of each subsystem can be integrated to achieve better organizational performance” (i.e. collaboration drive and regulate it). Generally, organizational tasks are carried out jointly to accomplish collaboration.

In practice, however, each department or business unit has its own operative goals that inhibit collaboration. When the goals of individual units are incompatible, the organization as a whole suffers. Capabilities in collaboration evolve as the goals of individual units become congruent. One method of achieving goal congruence (extent of agreement of the operative goals among departments/business units of the firm) is by adopting a business process orientation (McCormack and Johnson, 2001; Quiett, 2002). Davenport (1993) defines business process as a “specific ordering of work activities across time and place, with a beginning, an end, and clearly
identified inputs and outputs: a structure for action”. Typical examples of business processes include procurement, demand management, order fulfillment, new product development, customer relationship management, and cash to cash conversion (Lambert et al., 1998; Mejza and Wisner, 2001; Anupindi et al., 2000). Adapted from this literature, in this study Capabilities in Collaboration are defined as: *the degree to which a firm uses the information provided by internal functions, customers and suppliers to make business process decisions and collaborate in business processes.*

Examples of collaboration include, scheduling, planning and control, order fulfillment, new product development, etc. The ability of a participant to partner and its position in the supply chain are two important issues to be considered in building collaboration through a process-based SCPM. Ability to partner refers to the capability required to set up and manage the SCPM system (Otto and Kotzab, 2003). It is clear from exchange network theory (Benson, 1975; Cook, 1977) that the central connectedness of a partner (also known as Network Centrality) plays a major role in determining its ability to setup and control the process based SCPM system. Centrality of a participant allows it to understand the dynamics of the external environment better, gain greater visibility of supply chain working, and evolve goals for the supply chain in the best interest of the entire supply chain. Other players agree to these supply chain goals as these goals are set in the best interest of the entire supply chain (Lee, 2000). This in turn promotes a greater degree of collaboration.

To encourage collaboration, adoption of a business process orientation sets up performance measurement systems with a process focus by eliminating hierarchies and functional silos. Greater the level of adoption of a business processes orientation within the firm, greater is the degree of collaboration, as is evident from the following examples:

- Hyundai Motor Company traditionally treated its manufacturing, product development, and engineering functions as separate entities. As such, it consistently received low customer satisfaction ratings because there was no collaboration to resolve customer complaints. Service was slow and rarely resolved a customer problem to their satisfaction, as responsibility was passed from department to department. In the early 1990’s, Hyundai undertook an initiative to adopt a process view whereby production and sales were made jointly responsible to collaborate on production planning, scheduling, new product introduction, order launching, and delivery activities. Each function
abandoned its individual functional goals in favor of the common goal to achieve a higher level of customer satisfaction (Hahn et al., 2000).

- Caterpillar and Tri-state Industries have embarked on improving their new product development process. They have encouraged collaboration by changing their manufacturing, marketing, purchasing, and customer service departments into new product development teams. Adoption of cross-functional business process orientation helped them achieve goal congruence and collaboration among departments (Stevenson, 2001).

To encourage continued collaboration, dependence and commitment of the partners must be expressly recognized. This is explained from relationship marketing literature where “dependence” is the recognition by both partners in an exchange relationship that the relationship provides greater benefits than what either partner could attain alone (Dwyer et al., 1987; Mohr and Spekman, 1994). Commitment ensures preservation of the relationship. Again, from a relationship marketing theory perspective, commitment is defined as an "implicit or explicit pledge of relational continuity between exchange partners" (Dwyer et al., 1987). Commitment ensures that supply chain partners 1) work at preserving relationship investments by cooperating with exchange partners; 2) resist attractive short term alternatives in favor of the expected long-term benefits of staying with existing partners. Thus, both dependence and long term commitment help partners in sustaining SCI.

Collaboration is further supported through the incentives given to managers and workers to use the information to the mutual benefit of internal functions, as well as external suppliers and customers. As this can occur in varying degrees, any measurement must capture the extent to which supply chain players collaborate. This means the extent to which players participate in joint initiatives, resource sharing and mutual cooperation with other players. Collaboration can include the functions of demand forecasting, production planning, product design, development and delivery. This is important because supply chain partners will not participate unless they receive benefits that exceed their costs of participation (Cachon and Lariviere, 2001). Systems that provide a framework for partners to share benefits among themselves are commonly referred to as incentive sharing systems (Chen, 1999; Lee and Whang, 1999). Such systems ensure an equitable distribution of benefits and thus provide motivation for partners to participate in SCI efforts. There are several suggestions in the literature for implementing incentive sharing
systems. They include systems that rely solely on financial incentives based on contractual relationships such as ‘revenue-sharing’ and ‘profit-sharing’ contracts (Cachon and Lariviere, 2001) and those that are based on the contributions of individual firms to the joint performance of the supply chain such as ‘risk-sharing’ and ‘cost reduction’ (Lee, 2000).

Process-based performance measurement systems promotes collaboration by taking a systems approach (Holmberg, 2000). A systems approach implies consideration of the system as a whole rather than concentrating on its constituent parts (Johnson et al., 1963; Checkland, 1993). Accordingly, we argue that the emphasis should not be on measuring the performance of individual functional areas but on measuring the performance of the entire process. Several process based measures exist that could be deployed by a company. For example, Lockamy III et al. (2000) propose measuring the order fulfillment rate, procurement lead time, new product development lead time, number of new products developed, customer inquiry resolution time, customer satisfaction index, cash to cash cycle time, and total delivered cost. The choice of the most appropriate process-based measure is generally based on factors such as inclusiveness, universality, measurability, consistency, and non-redundancy of the process measures (Beamon, 1999; Melnyk et al., 2004). A process based performance measurement system emphasizes developing appropriate structures for accountability and responsibility within the firm (Eccles and Pyburn, 1992). Several companies have adopted process-based performance measurement systems to achieve a higher degree of goal congruence, as illustrated by the following examples:

- The 3M Company has historically maintained a high level of customer satisfaction and loyalty through its innovative products. It did so by closely managing its key processes as standalone functional-based activities. However, in the mid 1990’s 3M experienced a slowdown in the number of new product introductions, loss of market share, and decreasing customer service (measured by late deliveries, stock outs, and poor product quality). Managers discovered that the problems were due to function-based activities that worked to achieve function-based goals and discourage collaboration. 3M ultimately abandoned its function-based activities in favor of process based activities and adopted a process based measurement system. In turn, company-wide goals were established and collaboration was achieved. In about three years 3M was able to improve its performance (Lockamy III et al., 2000).
Based on these studies, we define SCI as *a state of achieving a high degree of both internal communication and collaboration capabilities (internal integration) among functional business processes and external communication and collaboration capabilities (external integration) among supply chain business processes.*

Next, we develop the theoretical basis for describing the possible interaction between SCPM and SCI. We integrate concepts from multiple theories, such as transaction cost economics, organizational theories, systems theory and relationship marketing, to develop the theoretical basis.

**Competency in Supply Chain Integration Sustainability (SCS)**

Extending the principles of RBV beyond a single firm to an entire supply chain suggests that supply chains may achieve superior performance in the short-term by developing SCI capabilities. If managed properly, the aggregation of these capabilities become competencies that can’t easily be matched by competitors (Stank et al., 2005). The RBV further suggests that developing competencies is the only way of sustaining capabilities over the long term. In other words, the interaction between complementary capabilities creates competencies that are difficult to mimic by competitors and are therefore sustainable over time. This suggests that the reason that SCI is not sustained, even in the presence of superior performance, is that it must be combined with SCPM to create a competency in Supply Chain Sustainability (SCS). In this study, we use the Resource Based View (RBV) (Barney, 1991) and Transaction Cost Economics (TCE) (Williamson, 1975; 1985) theories to explain how sustaining SCS is not a separate concept created by simply using SCI over the long term, but in fact is a competency created through the interaction between SCI and SCPM. Stated differently, SCI is sustained because it is a business competency created through the interaction between integration and evaluation capabilities. Only competencies have any degree of sustainability (Porter, 1991). Stank et al. (2005), and Day (1994) say that competencies are developed only through combinations of capabilities. However, they do not identify how the capabilities are combined – i.e. through moderation (interaction), or mediation. This study is the first to examine how the SCS is created. It is important because SCS prescribes how SCI, and its associated benefits, are sustained over the long-term thus giving the supply chain partners a competitive advantage.
The RBV and Transaction Cost Economics (TCE) theories explain how the interaction works to create competencies. First, by definition, the SCS competency is created by multiple capabilities. In this case, the capabilities of SCI and SCPM are both present. Second, SCI is created through the allocation of resources to achieve communication and collaboration capabilities (Kahn and Mentzer, 1996). This allocation is explained by RBV which says that firms first allocate resources internally to achieve internal integration. Third, the TCE explains that firms allocate resources to extend their internal capabilities externally (to achieve external integration) because it reduces the transaction costs associated with doing business across the supply chain. Fourth, the RBV explains why firms monitor internal functions through evaluation systems because the resources must be allocated and functioning monitored according to a plan to achieve integration. Without monitoring and evaluation, there is no way to tell whether resources have been allocated appropriately, whether internal integration is a success, or whether responsibility and corrective action have been taken for system failures. Fifth, the TCE explains why firms monitor and evaluate external partners. It does so because transaction costs must be measured and evaluated in order to discover whether system-wide transactions are becoming more efficient (declining transaction costs). It also explains how firms assign responsibility for system failures (rising transaction costs) and where corrective action should be taken by partners.

In summary, TCE says that firms must reduce transaction costs in order to stay competitive. In doing so, the RBV says that firms allocate resources internally and externally to improve business processes in order to reduce these costs. To ensure costs are reduced, the RBV explains that resources are also allocated to evaluate and monitor transactions and those responsible for transaction efficiency. To achieve transaction efficiency, the RBV says that internal functions and external partners (those responsible for transaction efficiency) must expend resources to communicate and collaborate with each other, otherwise, according to TCE the transaction costs simply get passed from one partner to the next rather than eliminated from the system.

**Objectives of this Study**

Despite the importance of sustaining supply chain integration, there is paucity of research concerning the development and application of theories to explain how to sustain it. There is no study describing how the relationship between supply chain integration and supply chain
evaluation system actually works to sustain SCI. To date, no study has examined whether the interaction between SCI and SCPM capabilities actually create competencies. These competencies are important because they are difficult to mimic by competitors and therefore lead to sustainability of the supply chain.

The literature review is summarized in Table 1. The extreme left-hand column describes the outcome of each study, i.e. the contribution to our model such as providing a model, findings, motivation, measures, etc. for supporting our model. The top row identifies the construct of interest. Each study addressing a specific construct, and its associated outcome, is listed in the field. As the matrix shows, there is a body of literature showing a positive relationship between a firm’s ability to integrate and to sustain the integration over the long term, and a contrasting body showing a negative or neutral relationship. This inconsistency between integration and sustainability and the paucity of theoretical research explaining this inconsistency creates the motivation for this study. This means that the elements needed to achieve SCI may be different than those needed sustain it over the long term. The remaining literature in Table 1, addresses the constructs and definitions we use in our model and measurement instrument.

To fill the void in previous research, we provide the theoretical foundation of how SCI and SCPM interact to create competencies that sustain integration along the supply chain. We conduct an empirical study to test our research model with supply chain managers. The model is shown in Figure 2.

**Figure 2. The research model**

The theoretical foundation leads us to offer the following four hypotheses:

*Hypothesis 1 (H1): Firms with greater capabilities in monitoring both internal processes and external processes achieve a higher level of supply chain evaluation capability.*
Hypothesis 2 (H2): Firms with greater capabilities in communication and collaboration among internal functions and external partners achieve a higher level of supply chain integration capability.

Hypothesis 3 (H3): Firms with greater capabilities in both supply chain integration and supply chain evaluation achieve a higher level of competency in sustaining supply chain integration.

Hypothesis 4 (H4): Firms with greater capability in supply chain evaluation achieve greater capability in supply chain integration.

METHODOLOGY
This empirical study used a Web survey to examine the relationships. In conducting the survey, we adopted the following steps:

Step 1: Constructs were defined based on prior literature.
Step 2: The measurement items were generated.
Step 3: The instrument was assessed for content validity by using modified Q-sort technique.
Step 4: The sample characteristics were specified.
Step 5: The reliabilities of the constructs were examined.
Step 6: A full-scale Web survey was launched.
Step 7: Final data analysis was conducted.

The constructs were defined based on prior literature. The initial instrument was developed by the researchers through several iterations of conceptualization and discussion. The initial version included a concept definition and several possible question options to represent each construct. The purpose was to conduct a Q-sort to allow a pilot group to choose 2-3 questions for each construct that would be used to develop an instrument to collect empirical data. The instrument was first tested for content validity using a modified version of the Q-sort procedure as outlined in McKeown and Thomas (1988). In this procedure, five university professors and five graduate students were used as a pilot group to test our questionnaire. They were first given the definitions of each construct and asked to choose the questions that best reflect the construct definition. During the first iteration, the pilot group was also asked to recommend revisions to their selected questions to make its meaning clearer. The results were collected and sufficient consensus was reached to allow the researchers to narrow the question options to two – three per construct. As a result of the comments given during the pilot study,
the questions were converted into statements to allow better coding of the responses using a Likert-like scale (1 – representing I strongly disagree to 5 – I strongly agree with the statement). The options were again given to the pilot group to conduct a second iteration. After the second iteration, at least seven members of the pilot group agreed on the statements, with all ten agreeing on the statements measuring the constructs of SCI and SCPM. The final statements are shown in Column 3 of Table 2. The final version of the instrument was then administered to senior supply chain managers in 27 firms as a part of the pilot study. At the end of the pilot study, Cronbach’s alpha (in Column 2 of Table 2) for each construct exceeded the established cut-off value of 0.70 required to establish the construct reliability (Cronbach, 1951; Nunnally, 1978). Hence, all the measurement items were retained for the final Web-survey.

Three thousand manufacturing units were randomly selected for full-scale Web survey from directories such as the APICS directory, Institute of Supply Management and Harris Info Source. The unit of analysis was an individual firm. Senior supply chain managers were selected and emails sent explaining the purpose of the research, and a URL link to the survey website. After three rounds of reminders usable responses were received from 102 firms. Our 3.4% response rate compares well with other web-based supply chain studies (e.g. Cousins et al., 2006). The characteristics of the organizations that participated in the study are shown in Table 3, including industry sector, title of the respondent and number of employees. Most of the participants were from electronics and computers, pharmaceuticals, automotive, industry machinery, food and textile industries. Industries with firms that made investments in integration initiatives were adequately covered. Most of the participants were upper level managers in the field of supply chain, purchasing, and operations. Nearly 55% of the firms had between 100 and 500 employees.

RESULTS AND DISCUSSION
We screened the data from the 102 firms for missing data, and univariate and multivariate outliers. There were no missing data or univariate outliers. However, we deleted from the data set one firm that was found to be a multivariate outlier, based on Mahalanobis Distance
The remaining 101 firms formed the basis for further data analysis.

Tests for non-response bias were carried out by comparing early respondents (responses received within the first 2 weeks) and later respondents (responses received within the third week or later) (Armstrong and Overton, 1977). A t-test of difference was conducted on number of employees and mean responses to each variable. No statistically significant differences were identified ($\alpha = 0.05$).

We verified the measurement model for each factor by conducting Confirmatory Factor Analysis using EQS 6.1 software. Each measurement model exhibited very good model fit with CFI greater than 0.90, SRMR less than 0.05, RMSEA less than 0.05 and insignificant Chi Sq. All factor loadings were statistically significant (shown in Table 4) indicating good convergent validity. The Lagrange multiplier (LM) test for omitted paths revealed no significant cross-loadings, indicating discriminant validity.

The hypotheses were tested using Multiple Regression. Regression results are tabulated in Table 5.

Based on our results, the linkages between capabilities in monitoring internal processes, external processes and supply chain evaluation capability (SCPM) are both significant, with capabilities in monitoring internal processes having a stronger effect on supply chain evaluation capability, therefore, H1 is fully supported. The linkages between capabilities in communication, collaboration and supply chain integration capability (SCI) are both significant, with capabilities in communication having a stronger effect on supply chain integration capability, therefore, H2 is fully supported. The linkages between SCI, SCPM and SCS are both significant, with SCPM having a much greater effect on SCS than SCI, therefore, H3 is supported. Based on our results, the relationship between SCPM and SCI is significantly positive, suggesting that as SCPM increase, SCI increases. Therefore, H4 is also supported.
The objective of this study was to examine the relationship between supply chain integration capability (SCI) and supply chain evaluation capability (SCPM) and their combined effect in creating a competency in sustaining supply chain integration (SCS). Theoretical lenses from multiple theories such as Transaction Cost Economics, Resource Based View and Systems Theory were used to explicate the interaction between SCI and SCPM in creating SCS.

The study developed a survey instrument that measures latent factors ‘capabilities in communication’, ‘capabilities in collaboration’, ‘capabilities in monitoring internal processes’, ‘capabilities in monitoring external processes’, ‘supply chain evaluation capability’ (SCPM), ‘supply chain integration capability’ (SCI) and ‘competency in supply chain integration sustainability’ (SCS). A web survey was administered to three thousand firms and usable responses were collected from 102 firms. After screening the data for outliers, responses from 101 firms were used for further analysis. Measurement model for each factor was verified using the confirmatory factor analysis using EQS 6.1 software. Content, convergent and discriminant validities were established.

A set of four hypotheses were tested using Multiple Regression technique. All the four hypotheses were supported. We found that both ‘capabilities in monitoring internal processes’ and ‘capabilities in monitoring external processes’ have statistically significant positive relationship with ‘supply chain evaluation capability’. Also, both ‘capabilities in communication’ and ‘capabilities in collaboration’ have statistically significant positive relationship with ‘supply chain integration capability’. The relationships between SCPM, SCI and SCS were both statistically positively significant, with SCPM having a stronger effect on SCS than SCI. And SCPM has a statistically significant positive relationship with SCI.

Contributions to Literature
This study makes three important contributions to literature.

First, this study is the first study to examine the relationship between supply chain integration capability (SCI) and supply chain evaluation capability (SCPM) and their combined effect in creating a competency in supply chain integration sustainability (SCS). This is important because not all integrated supply chains sustain the level of integration or its benefits over the long term. If companies in a supply chain are unable to sustain integration, then it would
lead to a tremendous waste of financial and temporal resources and consequently, harm the ability of the supply chain to stay competitive. The findings of this study suggest that both supply chain integration capability and supply chain evaluation capability help in the development of competency in supply chain integration sustainability, with supply chain evaluation capability having a stronger effect on supply chain integration sustainability than supply chain integration capability.

Second, this study is the first study to examine the relationship between SCPM and SCI. The findings of this study suggest that SCPM has a statistically significant positive relationship with SCI. This shows that supply chain evaluation capability is essential in nurturing supply chain integration capability.

Third, this study may be the first to define and measure various latent factors outlined in the previous subsection. Our testing of the psychometric properties of the measurement items for reliability, content, convergent and discriminant validities suggests that the measurement items have sound psychometric properties.

**Contributions to Practice**

This makes five important contributions to practice.

First, this study provides a perspective that achieving supply chain integration (SCI) is different from sustaining SCI (SCS). When companies in a supply chain develop a competency in sustaining supply chain integration, they derive long-term strategic benefits, and not temporary benefits. One of the major roadblocks to sustaining SCI is the lack of a proper supply chain evaluation system (SCPM). Development of supply chain wide evaluation system (SCPM) interacts with SCI to foster supply chain integration sustainability (SCS).

Second, SCPM requires not only the development of appropriate metrics but also a system to develop capabilities in monitoring internal and external business processes.

Third, while developing performance evaluation system at the supply chain level, there should be an effective allocation of resources in an inter-organizational system that facilitates measuring the performance of the external supply chain members to meet supply chain goals rather than local goals.

Fourth, while developing performance evaluation system at the firm level, there should be an effective allocation of resources in a system to monitor internal, firm level targets.
Fifth, managers should invest resources in developing capabilities in communication and collaboration in order to promote supply chain integration.

Limitations of the Study
While this study provides important results, there are two major limitations that must be addressed. Responses were collected from individual firms rather than multiple firms that constitute a supply chain. Prior research suggests that response rates will be abysmally very low when we collect data from multiple companies that constitute a supply chain (Radhakrishnan et al., 2007).

This study is limited by its dependence on perceptual self-reported data on capabilities and competency. However, it would be very difficult to obtain objective data for a study like this one. It is widely reported in the literature that managers are reluctant to share objective data with researchers (e.g. Kaynak and Hartley, 2006).

Directions for Future Research
This study provides a foundation for several types of future studies. First, supply chain researchers could empirically examine the relationship between SCI, SCPM and SCS by collecting perceptual data from multiple companies (at least a triad) that constitutes a supply chain. Second, comparing and contrasting the relationships between SCI, SCPM and SCS across different types of supply chains could be an interesting future research topic. For example, Lee (2002) and Fisher (1997) classified supply chains based upon the magnitude of supply and demand uncertainties faced: agile, functional, responsive and risk-hedging. Third, they could examine how usage of inter-organizational information systems influences supply chain integration.
REFERENCES


**Table 1: Literature supporting the model**

<table>
<thead>
<tr>
<th>Negative relationship between SCI and SCS</th>
<th>Capabilities in Communication lead to SCI</th>
<th>Capabilities in Collaboration lead to SCI</th>
<th>Positive relationship between Supply Chain Integration Capability (SCI) and SCS</th>
<th>Supply Chain Evaluation Capabilities (SCPM)</th>
<th>Capabilities in Monitoring Internal Processes</th>
<th>Capabilities in Monitoring External Processes</th>
<th>Investment In Resources Leads to Capabilities, which in-turn lead to Competencies</th>
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<td>Stank et al., 2005</td>
<td>Stank et al., 2005</td>
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<td>Lawrence and Lorsch, 1967; Stevens, 1990; Lee et al., 1997; Narasimhan and Jayaram, 1998; Johnson, 1999; Frohlich and Westbrook, 2001; Rosenzweig et al., 2003; Vickery et al., 2003; Droge et al., 2004; Bagchi et al., 2005</td>
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**MODELS:**
- Stank et al., 2005
- Narasimhan and Jayaram, 1998
- Frohlich and Westbrook, 2001
- Frohlich, 2002
- Rozenweig et al., 2003
- Vickery et al., 2003
- Eccles and Pyburn, 1992
- Holmberg, 2000
- Stank et al., 2005

**FINDINGS:**
- Boddy et al., 1998
- Spekman et al., 1998
- Holmberg, 2000
- Lapide, 2000
- Vinas, 2001
- Lambert and Pohlen, 2001
- KPMG Consultants report, 2003
- Upstate South Carolina Supply Chain
- Lawrence and Lorsch, 1967
- Stevens, 1990
- Lee et al., 1997
- Narasimhan and Jayaram, 1998
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- Frohlich and Westbrook, 2001
- Rosenzweig et al., 2003
- Vickery et al., 2003
- Droge et al., 2004
- Bagchi et al., 2005
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<th>Dwyer et al., 1987; Mohr and Spekman, 1994; Cachon and Lariviere, 2001</th>
<th>Holmberg, 2000; Lambert and Pohlen, 2001; Johnson et al., 1963; Checkland, 1993</th>
<th>Armistead and Mapes, 1993; Pagell, 2004</th>
<th>Stevens, 1990; Anderson and Lee, 2000; Aryee et al., 2005; Bechtel and Jayaram, 1997; Holmberg, 2000; Lambert and Pohlen, 2001; Morgan, 2004; Motivation: Dwyer et al., 1987; Mohr and Spekman, 1994; Cachon and Lariviere, 2001</th>
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<tr>
<td>Capabilities in Communication</td>
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<td>COM2- My firm has the ability (hardware, software and networking equipment) to communicate effectively with its suppliers.</td>
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<td>COM3- My firm has the ability (hardware, software and networking equipment) to communicate effectively with its customers.</td>
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<td></td>
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<td>COLL2 - My firm effectively uses the information it receives from its customers to make business process decisions.</td>
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<td>COLL3 - My firm effectively uses the information it receives from its suppliers to make business process decisions.</td>
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<td>COLL4 - My firm collaborates with its suppliers in critical business processes (such as scheduling, new product development, planning and control, order fulfillment, shipment).</td>
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<td>COLL 5- My firm collaborates with its customers in critical business processes (such as scheduling, new product development, planning and control, order fulfillment, shipment).</td>
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<td>Capabilities in Monitoring Internal Processes</td>
<td>0.86</td>
<td>MINT1 - My firm sets congruent goals across internal business processes and functions that do not conflict with supply chain goals.</td>
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<td></td>
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<td>MINT2 - My firm has the ability to effectively measure, monitor, and control internal business processes.</td>
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<td>Capabilities in Monitoring External Processes</td>
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<td></td>
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<td>MEXT2 - My firm has the ability to effectively measure, monitor, and control external business processes.</td>
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<tr>
<td>Supply Chain Evaluation Capability</td>
<td>0.77</td>
<td>SCEC1 - Overall, the companies in my supply chain have evaluation systems that can monitor and control each others performance relative to the common goals agreed upon by all members.</td>
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<td>SCEC2 - Overall, the companies in my supply chain have evaluation systems that clearly specify performance metrics, responsibilities and accountability of all members.</td>
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<td>Supply Chain Integration Capability</td>
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<td>SCIC1 - Overall, the companies in my supply chain have the connectivity and willingness to provide business information to each other.</td>
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<td>SCIC2 - Overall, the companies in my supply chain effectively use the information shared to make business decisions such as what/when to schedule production, how much inventory to hold, cost, when to ship, and product development.</td>
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<td>Competency in Supply Chain Integration Sustainability</td>
<td>0.75</td>
<td>SCS1 - Overall, my supply chain has achieved integration of all supply chain members.</td>
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<td>SCS2 - Overall, the companies in my supply chain have been able to sustain the integration and its associated benefits over the long-term.</td>
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<td>Manager - Manufacturing</td>
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Table 4: Factor analysis results

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<td>COM3</td>
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<td>0.98*</td>
<td>0.96</td>
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<td></td>
<td>COLL2</td>
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<td></td>
<td>COLL3</td>
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<td>COLL4</td>
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<td>Capabilities in Monitoring External Business Processes</td>
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<td>0.75*</td>
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<td>Supply Chain Evaluation Capability</td>
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<td>Competency in Supply Chain Integration Sustainability</td>
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<td>SCS2</td>
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* Significant at 5% level of significance
Table 5: Multiple regression results

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<td>Supply chain integration capability</td>
<td></td>
<td>0.47*</td>
<td>9.27</td>
<td></td>
</tr>
<tr>
<td>H4: Supply chain integration capability</td>
<td>Supply chain evaluation capability</td>
<td></td>
<td>0.68*</td>
<td>10.05</td>
<td>0.45</td>
</tr>
</tbody>
</table>

* p < 0.01 (significant)
Founded in 1892, the University of Rhode Island is one of eight land, urban, and sea grant universities in the United States. The 1,200-acre rural campus is less than ten miles from Narragansett Bay and highlights its traditions of natural resource, marine and urban related research. There are over 14,000 undergraduate and graduate students enrolled in seven degree-granting colleges representing 48 states and the District of Columbia. More than 500 international students represent 59 different countries. Eighteen percent of the freshman class graduated in the top ten percent of their high school classes. The teaching and research faculty numbers over 600 and the University offers 101 undergraduate programs and 86 advanced degree programs. URI students have received Rhodes, Fulbright, Truman, Goldwater, and Udall scholarships. There are over 80,000 active alumnae.

The University of Rhode Island started to offer undergraduate business administration courses in 1923. In 1962, the MBA program was introduced and the PhD program began in the mid 1980s. The College of Business Administration is accredited by The AACSB International - The Association to Advance Collegiate Schools of Business in 1969. The College of Business enrolls over 1400 undergraduate students and more than 300 graduate students.

**Mission**

Our responsibility is to provide strong academic programs that instill excellence, confidence and strong leadership skills in our graduates. Our aim is to (1) promote critical and independent thinking, (2) foster personal responsibility and (3) develop students whose performance and commitment mark them as leaders contributing to the business community and society. The College will serve as a center for business scholarship, creative research and outreach activities to the citizens and institutions of the State of Rhode Island as well as the regional, national and international communities.

The creation of this working paper series has been funded by an endowment established by William A. Orme, URI College of Business Administration, Class of 1949 and former head of the General Electric Foundation. This working paper series is intended to permit faculty members to obtain feedback on research activities before the research is submitted to academic and professional journals and professional associations for presentations.

An award is presented annually for the most outstanding paper submitted.