Toward the development of an integrated model of technology internalization within the supply chain context

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Abstract

Purpose – Integrating information technologies in supply chains is becoming increasingly more important and challenging. The purpose is to develop a framework for understanding antecedents to internalizing technologies in supply chains.

Design/methodology/approach – A literature review covering over 30 years of interdisciplinary research was used as the theoretical underpinning for developing the supply chain internalization model (SCIM). A series of 93 personal interviews with members of a major automotive supply chain were conducted, and detailed qualitative data collected, to identify a set of significant antecedents to technology internalization.

Findings – The results of the research is an empirically derived framework, the SCIM, including a comprehensive set of 79 directional antecedents useful for academicians and practitioners for understanding factors impacting how information technologies are internalized in organizations and supply chains.

Research limitations/implications – Empirically testing the proposed directional relationships can be used to confirm their validity and measure the relative strengths of individual or interacting antecedents. The relationships outlined in the SCIM should be tested in a diverse array of industries in order to generalize the model. In addition, the relative strength of the factors should be tested since in different contexts. For more robust understandings, moderating and mediating effects amongst the variables should be identified.

Practical implications – Practitioners can use the SCIM as a source for established guidelines for developing strategies for implementing information technologies.

Originality/value – This paper lays the groundwork for facilitating the internalization of information technologies in supply chains and is flexible enough to accommodate future research into technology internalization.

Keywords Supply chain management, Communication technologies

Paper type Research paper

Supply chain management (SCM) is an important success factor for companies challenged by weakened economies, the proliferation of globally sourced products, improved functional integration, and rapid technological change (Kerr, 2001). While in 2003, $936 billion or 8.5 percent of the US GDP was spent on logistics functions (Wilson, 2004), still, collaborative efforts to manage supply chains are necessary to

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continually improve relationships and overall supply chain performance (Chandrashekar and Schary, 1999). Investments in and the integral use of information technologies (IT) are important elements of well-managed supply chains. One of today's challenges is to ensure that IT is integrated and used properly in supply chains.

Since, supply chains are often complex systems of interdependent activities and processes associated with the flow of products, services and information from the original supplier of raw materials through to the final consumer (Handfield and Nichols, 1999), managing them is often facilitated by IT (Manrodt and Davis, 1993). The most important priority for shippers is visibility along the supply chain (Kerr, 2001). To achieve product level visibility, firms are adopting a wide variety of IT (e.g. electronic data interchange, global positioning satellites and transportation management systems) among supply chain partners.

Therefore, it is important to understand not only how firms within supply chains adopt technologies, but also more importantly, how these technologies are internalized in daily operations. Internalization is the effective and consistent use of a technological innovation over time by its users. Thus, a comprehensive model of internalization, is needed to capture the complexities of relationships between supply chain members. This paper presents such a model – the supply chain internalization model (SCIM) – to address this need and identify factors which lead to technology internalization in a supply chain context.

Internalization should be of interest to scholars and practitioners because it more accurately reflects an entity's long-term behavior. As a measure of effective and consistent use of the technological innovation by its users, internalization provides an assessment of technology use over time and enables the establishment of metrics geared toward assessing (usage) outcome characteristics (e.g. satisfaction levels with the innovation, frequency of use of the innovation, and measures of how an innovation is used). The proposed model fulfills several key functions and is significant based on the subsequent rationale.

First, this model represents an initial interdisciplinary approach to modeling multi-tier IT internalization within a supply chain. SCIM incorporates social, environmental, organizational, and individual behavioral dynamics in a supply chain context as potential antecedents of internalization.

Second, the model contains a taxonomy of 79 antecedents to internalization. SCIM is rigorously grounded in a theoretical foundation, which can facilitate meaningful hypothesis development and testing to predict the factors influencing technology internalization and can serve as a basis for future empirical validation.

Third, the unit of analysis can be either the individual or the organization based on Rogers' (1962) notion that different members of a social system go through the same innovation decision-making process. Therefore, potential ecological fallacies (Singleton and Bruce, 1993) associated with unit of analysis mixing can be avoided. Also, if a representative sample of potential adopters within the organization's population is included in the data collection process, conclusions can be drawn about the organization as the unit of analysis.

Finally, having an understanding of how innovations are internalized specifically within supply chains is important to researchers and practitioners alike due to the interconnectedness of supply chain members. This interconnectedness suggests that

innovation internalization within supply chains will be different from other environments.

This paper aims to achieve two main objectives:

(1) to propose a framework for understanding the relationships leading up to IT internalization outcomes and subsequent usage behaviors in the context of SCM; and

(2) to identify specific factors that influence supply chain partners to internalize innovative IT.

The next section contains an interdisciplinary review of prior research on technology adoption including theories pertinent to the supply chain context. The subsequent section conceptualizes the theoretical framework for the proposed model based on a grounded theory approach of 93 interviews. A discussion of how the model can be applied is presented followed by conclusions and suggestions for future research.

Theoretical background

IT adoption is the subject of a significant amount of research in SCM (Edwards *et al.*, 2001; Germain, 1996; Williams, 1994), information systems (Gallivan, 2001; Moore and Benbasat, 1991), and the marketing literature (Moreau *et al.*, 2001; Gatignon and Robertson, 1989). Several key theoretical models are utilized to study individual adoption and usage behavior within these domains including the Innovation Diffusion Theory (IDT) (Rogers, 1962), the Theory of Reasoned Action (TRA) (Fishbein and Icek, 1975), and the technology acceptance model (TAM) (Davis *et al.*, 1989). These models are applied to explain adoption and usage of technologies within the context of a stand-alone entity such as an organization. While important in the context of their studies, individually, these models lack the robustness to capture the boundary spanning interactions and influences that exist in supply chains.

Adoption is a choice to use or reject an innovation and occurs at the point in time when the adopting entity chooses to make the adoption decision. This decision may lead to a state of discontinuance, resulting in the non-use of the technology (Parthasarathy and Bhattacherjee, 1998). The continued use of the innovation represents a state other than discontinuance or adoption, for which we introduce a new concept of internalization. Furthermore, a majority of the studies based on these models used intention to adopt as the dependent variable (Agarwal and Prasad, 2000; Davis, 1989), which do not precisely measure actual adoption behavior.

Many theories and models have been offered to explain technology adoption in various organizational settings. However, given the multi-tiered interdependent relationships along a supply chain, a set of germane theories is required to encompass the diversity of issues applicable within this context. As such, this research utilizes three theories – General Systems Theory (GST) (von Bertalanffy, 1968), IDT (Rogers, 1962, 1995), and TRA (Fishbein and Icek, 1975) – to theoretically ground SCIM.

General systems theory

Systems are comprised of multiple interdependent hierarchical levels of nested subsystems, affecting the overall larger system (Miller, 1978). Systems can be defined as open or closed depending upon the level of external boundary permeability, which exists on a continuum from high to no feedback. Business organizations are considered

open systems since they interact with and are affected by outside entities' established boundaries. Organizational systems communicate with and react to their environment through input and output mechanisms (e.g. information exchange).

This business context makes GST a versatile theory which has been applied to a variety of disciplines. Bojovic (2002) used GST to study rail freight car fleet sizing citing its usefulness for understanding complex managerial decisions related to transportation asset management. McLeod (1995) applied GST to firms seeking competitive advantage through IT. Naumann and Lincoln (1989) suggested that GST could be applied in an industrial marketing context for theory building and applied research. These studies cut across the SCM, IT and marketing disciplines providing a precedent for applying GST within a cross-disciplinary business context.

A system can be composed of a set of social, technological, or individual partners cooperating toward a mutually shared purpose (Yndestad, 2003). von Bertalanffy's (1968) GST enables SCM researchers to effectively deal with a complex array of interdependent variables (Baggett, 1983) including the macro (supply chain) and micro (participative supply chain members) levels. A well-managed supply chain is a system consisting primarily of open, boundary spanning organizations, cooperating with each other toward a common goal such as lowest landed cost for the final customer. As subsystems of the larger supply chain, supply chain members need to develop and integrate structural and functional strategies compatible with system goals, which are necessary for synergistic organizational growth (Bagchi and Skjoett-Larsen, 2003). Since, supply chains are systems of interdependent subsystems, it is important to understand the relationships between these inter-dependencies. GST offers a firm theoretical grounding to examine these relationships.

Innovation diffusion theory

According to Rogers (1995, p. 11), "diffusion is the process by which an innovation is communicated through certain channels over time among members of a social system." A social system is comprised of individuals or organizations sharing similar knowledge and goals. Diffusion of innovations occur across systems at the macro (system) level and is comprised of four components:

(1) the innovation;

(2) the communication process;

(3) time; and

(4) social system members (Kettinger, 1999).

These are also components of supply chains where the innovation is the logistics information system, and the communication process represents how information is communicated. Time has always been a critical issue for supply chains and the social systems are represented by the supply chain members themselves.

Well-managed supply chains require shared knowledge, common goals, and consistent information exchanges, and supply chain processes between the supply chain members. The shared information and supply chain processes are increasingly integrated through logistics information systems (Dadzie *et al.*, 2000). Further, organizations cannot communicate or manage such communications with each other without the involvement of individuals. Since, IDT is useful to understand IT diffusion

in among social system members (Rogers, 1995), and business organizations in particular (Agarwal and Prasad, 1998a; Baskerville and Pries-Heje, 1998), it would also be appropriate for supply chains since these are in effect interdependent social systems in a business context. While GST provides the theoretical underpinning for the study of general relationships between social system members, IDT provides grounding for understanding specific relational behaviors – diffusion and adoption of innovations among supply chain members– in the context of these systems.

Theory of reasoned action

TRA, which focuses on individual behaviors can be useful in understanding how innovations are internalized within supply chain organizations. The TRA (Fishbein and Icek, 1975) provides a basis for predicting human behavior and contends that an individual's intention to behave is determined by two predominant factors:

(1) an individual's attitude toward the behavior; and

(2) the subjective norms about the behavior.

An attitude toward a behavior is influenced by an individual's assessment that engaging in a specific behavior will lead to a specific outcome. Subjective norms are based on normative beliefs about whether or not a specific behavior exhibited by an individual will gain approval by his/her referent group(s). The TRA assumes that individuals behave rationally and that these behaviors are undertaken voluntarily. Therefore, if behaviors are volitional in nature, then understanding intentions to behave should increase behavior (e.g. internalization) predictability. Predicting internalization behaviors will help improve information coordination along supply chains.

Overall theoretical underpinnings

The discussion above suggests that together, these theories help researchers to understand IT internalization in a supply chain context by providing insight into three behaviorally linked and interdependent activities. For example, it is clear that supply chains consist of systems of organizations which in turn have systems (or subsystems) of individuals. Since, innovations are diffused through social systems (involving individuals), it is necessary to understand the interplay between overall supply chain systems and their affiliated subsystems. This necessitates a theoretical understanding of how innovations are diffused within and across systems at the macro as well as the micro level. It also gives researchers an understanding and a strong foundation from which future hypothesized relationships can be proposed and tested.

Methodology

To provide insights into the research objectives, a two step approach was taken. First, an extensive review of 1,800 articles related to innovation adoption and diffusion was undertaken in the supply chain management, marketing, management information systems, and social psychology domains. Each article was coded for dependent and independent variables. This provided the foundation for conducting the second step in the research design, personal interviews. Ninety-three (53 men and 40 women) interviews with various members of a US automotive supply chain representing a diverse cross-section of organizations, geographic regions,

and individuals were conducted to develop – in conjunction with the literature review – the framework for understanding the internalization process. A detailed discussion of the methodology follows.

Grounded theory

The present research study is exploratory in nature. As such, a grounded theory approach (Glaser and Strauss, 1967) was taken to derive the SCIM framework. Grounded theory is the discovery of theory from systematically identified data where the theory is inductively derived from the study of the phenomenon under consideration (Strauss and Juliet, 1990). DeVreede *et al.* (1998) suggest that theory emerges as an iterative process throughout the data collection and analysis protocols. This approach is appropriate for the present research (Pappu and Mundy, 2002), theory building, and has been used for examining supplier relationships in the automotive industry (Flint and Mentzer, 2000).

In this particular context, a grounded theory approach is appropriate as the objective is to develop a framework for understanding a new construct, internalization. In addition, grounded theory has been used in SCM research in the past (Carter and Dresner, 2001). Specifically Carter *et al.* (2003) use grounded theory to examine factors related to adoption and implementation of an internet-based technology.

Interviewee selection

The sample of organizations introduced to a web-based technology known as the collaborative visibility network (CVN) was systematically and purposefully chosen. This technology, originally conceived by the automotive organization and jointly developed, promoted, and ultimately mandated in conjunction with the 4PL, is aimed at providing part level visibility to all members of the automotive supply chain. CVN enables part-level visibility to entire supply chains as goods are moved through them. CVN contains several unique features including a customer management capability that enables suppliers, customers, and receiving locations to update parts and packaging information via the internet. Additionally, CVN contains an order management feature that facilitates the viewing and tracking of shipments or part-level detail. A business intelligence mechanism includes updated interactive reporting and analysis capabilities to support operational and payment processes. A shipping order confirmation capability enables verification of quantities and dates through an advance ship notice (ASN). Receiving information is tracked including the arrival of a trailer at a receiving facility, the arrival of a trailer when the system is missing shipping notice information, and when a trailer has been unloaded at the receiving facility. Finally, CVN has the capacity to monitor hot-parts inbound to the receiving facility or in the facility yard.

CVN provides benefits to all members of a supply chain through:

(1) establishing visibility to the entire supply chain;

(2) maximizing the ability to modify manufacturing schedules due to supply changes;

(3) gaining improved inventory control;

(4) reducing inventory carrying costs;

(5) increasing customer satisfaction through improved order fulfillment; and

(6) reducing out-of-stock scenarios.

Using this web-based technology to examine the factors impacting internalization across a supply chain is useful since the innovation was developed solely for providing part-level visibility and management by a 4PL. In order to get a representative cross-section of the user population, organizations were selected from five different geographic regions across the US to account for possible geographic differences. Organizations were selected based on differences in:

(1) degree of geographic influence – rural versus urban location;
(2) organizational size;
(3) union versus non-union enterprise;
(4) organizational stage of adoption; and
(5) truckload (TL) and less than truckload (LTL) shippers, manufacturers and distribution facilities.

Individual internalizers varied along:

(1) multiple buying center roles;
(2) experience with technology;
(3) management versus line personnel;
(4) level of training;
(5) varying degrees of supply chain management orientation;
(6) tenure with the organization;
(7) tenure in current position;
(8) education;
(9) gender; and
(10) age.

Members of a 4PL and a major US automotive company, who collectively designed, developed, and implemented the product, were also interviewed. Discussions were conducted with initial product developers, customer service representatives, marketing staff personnel, key management players, IT specialists, training coordinators, and operations staff. The diversity and range of individuals with whom the researchers conversed provided a rich description of the form and function involved in the five phases of product development – idea generation, screening, evaluation, development and commercialization (Perreault and McCarthy, 1999). The purpose of this was to get a clearer picture of some of the 4PL individuals' responsibilities for developing the product and a better picture of what the technology is and how it is practicably implemented.

Data collection

An interview guide, consistent with Cassell and Symon (1994), was created to aid the researchers. Semi-structured questions (see Appendix) were reformulated throughout the interview process over the course of a six-month period as new topics emerged. The two-on-one (two researchers simultaneously with one member of the supply chain) interviews were tape-recorded. The researchers debriefed the interviews at the end of each day. Notes were compared, consolidated, and matched up to tapes of the

interviews to corroborate any discrepancies in the notes. Individuals were interviewed at their locations, which included manufacturing, warehousing, order fulfillment facilities, and corporate headquarters. A number of interviewees granted the researchers access to shop floor facilities so operational activities could be observed first hand. Figure 1 shows the breakdown of interview participants.

Data were collected to theoretical saturation (Eisenhardt, 1989; Yin, 1994), which involves the gathering of data until repetitions occurred. Interview analysis was used to obtain corroborating and rebutting findings. The researchers collected contemporaneous notes during the interviews. The notes included contact summary sheets identifying interviewees by name and title. Interview notes were summarized during the researchers' debriefing sessions after each session. Notes were coded based on the conceptual framework derived from the literature review and general research questions. Interviews were also recorded, transcribed, and coded by the researchers. The summarized and coded notes were compared to the coding structures crafted from the transcribed tapes. New findings resulting from the interviews were incorporated in subsequent interviews to confirm them across the supply chain.

Within-case analysis was employed at the end of the interviews as suggested by Eisenhardt (1989). Data read and judged to be relevant to the study were retained while irrelevant data were discarded. Consistent/repeat themes and factors were collapsed from interview data and ranked in order of the frequency a theme surfaced in the interviews. These factors were mapped to the literature review to identify the existence of research constructs to include in the SCIM model.

Follow-up visits or telephone interviews supplemented the initial conversations. Three months into the data collection process, several middle and upper level managers within various manufacturing and logistics companies, were re-contacted to confirm preliminary findings and suspected causal relationships. The validation process was replicated with a different group of managers when all the interviews were completed. Internalization factors were then summarized and coded into categories based on theoretical foundations within the literature. The source of the constructs may be found in Table I.

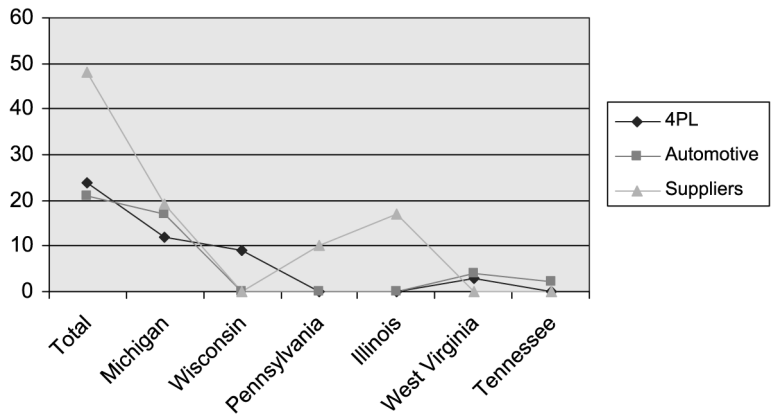

Figure 1.
Distribution of interviewees

Independent variable taxonomy	Construct definition	Definition source
Technological		
Perceived ease of use	The degree to which an individual believes that a particular technology is effortless to use	Davis (1989)
Perceived usefulness	The degree to which an individual believes that a particular technology will enhance an individual's job performance	Davis (1989)
Relative advantage	The degree to which an innovation is perceived as an enhancement to the idea it replaces	Rogers (1995)
Compatibility	The degree to which an innovation is perceived as being consistent with existing values, past experiences, and needs of potential adopters	Rogers (1995)
Complexity	The degree to which an innovation is perceived as difficult to understand and use	Rogers (1995)
Trialability	The degree to which a user can have an experiential test or trial of the innovation	Rogers (1995)
Observability	The degree to which the results of an innovation are visible to others	Rogers (1995)
Satisfaction with existing system	The degree to which the existing system meets the needs of an organization	Chau and Tam (2000)
Attitude toward technology	The degree to which an individual likes various attributes of the technology	Burkhardt and Brass (1990)
Technological skill level	The individual's aptitude for using computer systems and the length of time the individual has used technology	Thompson *et al.* (1994)
Prior technological knowledge	The individual's background and experience with technology	Cavaye (1996)
Willingness to learn	The degree to which an individual values learning as an instrument to improvement	Sinkula *et al.* (1997)
Computer anxiety	An individual's apprehension or even fear when he is faced with the possibility of using computers	Simonson *et al.* (1987)
Modal compatibility	The degree to which the potential adopter can physically integrate the innovation based on the existing technological infrastructure	Kaefer and Bendoly (2000)
Incremental versus radical	A radical technology is a new product that incorporates a substantially different core technology and provides substantially higher customer benefits relative to previous products in the industry	Chandy and Tellis (1998)

Table I.
SCIM variable taxonomy

(*continued*)

Independent variable taxonomy	Construct definition	Definition source
Perceived benefits of the technology	The degree to which the new technology resolves existing problems or provides new business opportunities	Beatty *et al.* (2001)
Procedural loopholes	The extent to which users implement procedural deviations to circumvent technological standard operating procedures	Author proposed
Environmental		
Dynamism	The ability to predict competitor moves and customer demands	Rai and Bajwa (1997), Miller and Friesen (1982)
Heterogeneity	Variations in the environment which include customer buying habits, nature of the competition and market uncertainty	Rai and Bajwa (1997), Miller and Peter (1982)
Hostility	Competitive pressures faced by the organization which include price, product quality and smaller product markets	Rai and Bajwa (1997), Miller and Friesen (1982)
Organizational		
Organizational power	The perceived gain in organizational power resulting from the adoption of the new technology	Markus and Robey (1983)
Technological orientation	A firm with the ability and will to acquire a substantial technological background and use it in the development of new products	Gatignon and Xuereb (1997)
Champion	A key individual who actively and vigorously promotes an individual's personal vision for using information technology, pushing the project over and around approval and implementation hurdles	Beath (1991)
Opinion leadership	The degree to which an individual is able to influence other individuals' attitudes informally in a desired way with relative frequency	Rogers (1995)
Cost	The perceived cost relative to the perceived benefit derived from implementing the innovation	Premkumar and Nilakanta (1994)
Task-technology fit	The extent to which a technology provides features and support that fit the requirement of the task	Goodhue and Thompson (1995)
Prior similar experience	The extent to which an organization has experience with a similar technology to that which is being adopted	Heide and Weiss (1995)
Centralization	The degree to which power and control in a system are concentrated in the hands of relatively few individuals	Rogers (1995)

(*continued*)

Table I.

Independent variable taxonomy	Construct definition	Definition source
Formalization	The degree to which an organization emphasizes following rules and procedures in the role performance of its members	Rogers (1995)
Top management support	The degree of top management vision, commitment, and involvement in the decision to adopt the new technology	Premkumar and Ramamurthy (1995)
Organizational skills and resources	The degree to which a new product development/adoption project fits with a firm's skills and resources	Song and Parry (1997)
Acceptance of authority and direction	The degree to which an individual accepts his/her manager's authority, feedback and instructions	Oliver and Anderson (1994)
Voluntariness	The degree of volitional control that end users have over adoption and usage	Karahanna *et al.* (1999)
Organizational culture	The set of beliefs, basic assumptions, key values, and understandings shared by most members of an organization about how people should behave at work and what tasks and goals are important	Gordon and Gordon (1992)
Process experience	The degree to which the adopting entity has prior experience with the new process	Author proposed
Individual		
Near term consequences	The degree to which an individual believes that using a technology will enhance the performance of his/her job	Cheung *et al.* (2000)
Long term consequences	The degree to which an individual believes that using a technology will increase opportunities or provide more meaningful work	Cheung *et al.* (2000)
Intrinsic motivation	The human need to be competent and self-determining in relation to the environment	Pullins (2001)
Job satisfaction	The degree to which an employee feels positive about an individual's work described as affective reactions toward the work situation	Swift and Campbell (1998)
Management of user expectations	The extent to which internal and external sources of communication in the context of an individual's past experience are adequately addressed	Ryker *et al.* (1997)
Personal innovativeness	The willingness of an individual to try out an innovation	Agarwal and Prasad (1998b)
Supply chain orientation	The degree to which an individual understands the supply chain management concept	Author proposed
Resistance to change	The degree to which an individual is unwilling to modify his/her current operations to accommodate the new technology	Edwards (1985)

Table I.

(*continued*)

Independent variable taxonomy	Construct definition	Definition source
Cognitive overload	The extent to which an individual is exposed to excessive amounts of information causing him to experience cognitive clutter	Sweller (1999)
Attitude toward company	The extent to which an individual experiences positive feelings toward his/her organization	Author proposed
Attention to detail	The degree to which an individual is meticulous in executing an individual's job tasks	Author proposed
Similar job responsibilities	The degree to which an individual's prior responsibilities match his/her present tasks associated with the new technology	Author proposed
Self-efficacy	An individual's perception of efficacy in performing specific computer-related tasks within the domain of general computing	Marakas *et al.* (1998)
Communication		
Information exchange	The extent to which parties in the channel relationship actively exchange information that could facilitate business activities with each other	Li and Dant (1997)
Formal communication channels	The established mechanisms within an organization for facilitating information exchange and dispersion of ideas	Damanpour (1991)
Training		
Training availability	The extent to which training of a particular technology is available	Rai and Patnayakuni (1996)
Training effectiveness	The extent to which individuals consider their training to have been effective	Hunter (1999)
Experimentation	To extent to which the organization encourages and supports individuals to engage in trial and error activities with the technology	Lassila and Brancheau (1999)
Risk		
Management risk position	The extent of organizational, managerial and financial risk acceptable by top management	Grover (1993)
Willingness to take risk	The willingness of an individual to engage in activities which may lead to loss or unintended negative consequences	Sultan and Chan (2000)
Risk taking climate	The sense of riskiness and challenge in the job and organization	Ettlie and Vellenga (1979); Litwin and Stringer (1968)

(*continued*)

Table I.

Independent variable taxonomy	Construct definition	Definition source
Trust		
Technology trust	An individual's willingness to be vulnerable to the information systems technology based on expectations of technology predictability, reliability and utility and influenced by the individual's predilection to trust technology	Lippert (2001)
Interpersonal trust	The willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party	Mayer *et al.* (1995)
Inter-organizational trust	The extent to which one party has confidence in an exchange partner's reliability and integrity	Morgan and Hunt (1994)
Inter-organizational relationships		
Dependence	A supply chain member's ability to influence the perceptions, behavior and decision making of another supply chain member	El-Ansary and Louis (1972)
Exercised power	The nature of relationships between supply chain members with regard to power and dependence	Premkumar and Ramamurthy (1995)
Customer involvement	The extent to which customers are involved in the development of the innovation	Zairi (1992)
Process change	The adopting entity's perception of an inter-organizational change in processes	Author proposed
Accountability	The degree to which a supply chain member is held accountable for an individual's responsibilities within the supply chain	Author proposed
Organizational roles		
User	Those members of the organization who use the purchased products and services	Webster and Wind 1972
Influencer	Those individuals who influence the decision process directly or indirectly by providing information and criteria for evaluating alternative buying actions	Webster and Wind 1972
Decider	Those individuals with authority to choose among alternative buying actions	Webster and Wind 1972
Buyer	Those individuals with formal responsibilities and authority for contracting with suppliers	Webster and Wind 1972

Table I.

(*continued*)

Independent variable taxonomy	Construct definition	Definition source
Gatekeeper	Those individuals who control the flow of information (and materials) into the buying center	Webster and Wind 1972
Perceived norms		
Subjective norms	The individual's perceptions of the social pressures to adopt or not adopt (continue using or stop using) the technology	Karahanna *et al.* (1999)
Normative beliefs	The perceived social pressure to perform or not to perform a behavior	Ajzen (1992)
Motivation to comply	The normative beliefs an individual attributes to what relevant others expect of him with respect to adopting an information technology as well as his/her motivation to comply with those beliefs	Karahanna *et al.* (1999)
Demographic		
Organizational size	The firm's overall size and market position	Doney and Cannon (1997)
Geographic influence	The extent to which an organization's location is urban	Kwak *et al.* (2003)
Job tenure	The length of time an individual has spent within an organization	Agarwal and Jayesh (2000)
Education	The highest level of education achieved by an individual	Self-report
Gender	Female or male	Self-report
Age	Chronological age of individual	Self-report

Table I.

Findings

Proposed relationships

After the literature review was conducted, a comprehensive conceptual framework was developed. This framework incorporated significant antecedents identified in the cross-functional research streams and included empirically derived directional findings between these antecedents and technology adoption. Grounded in the adoption literature, they are incorporated in the SCIM because this model is an extension of the technology adoption research. Since the dependent variable is related to technology adoption (but not the same), the directional relationships are presented as propositions which should be tested.

The factors included in the initial conceptual model were validated by the information gleaned from the interviews. The interviews provided insight suggesting which of the factors identified in the original conceptual framework were most important leading to internalization. Subsequently, the conceptual model was reduced to include those factors identified in the interviews. In some instances, constructs did not exist in the literature for the specific concepts identified during the interviews. In these instances, new scale items were developed and, based on the interview results, directional relationships were posited between those constructs and internalization.

Figure 2 shows directional relationships based on empirical findings from this research in a dynamic framework for understanding the internalization of innovations

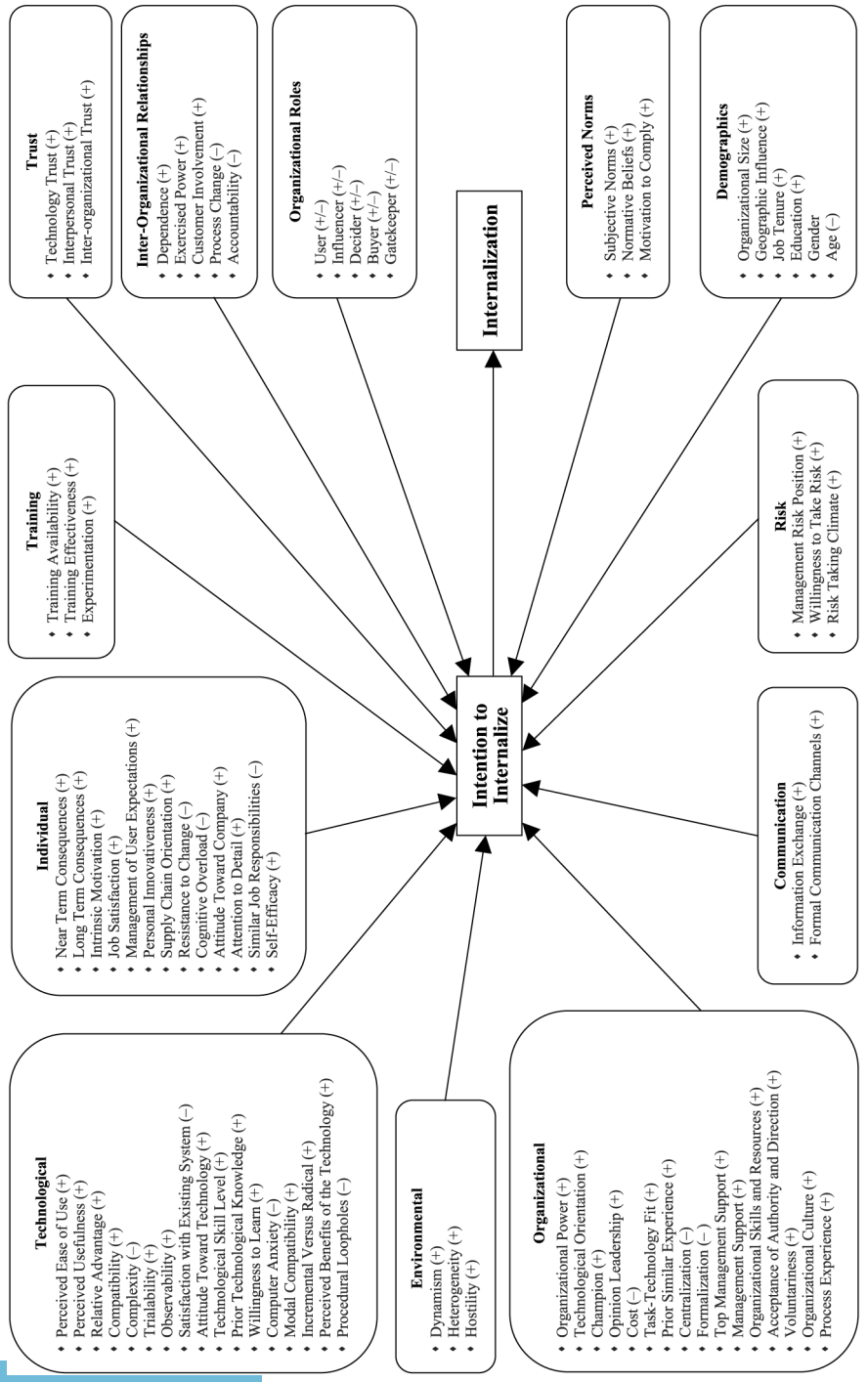

Figure 2.
Supply chain internalization model

throughout supply chains, thus providing a much needed measure of effective longitudinal IT usage. The SCIM consists of seventy-nine proposed interdependent relationships between predictor factors and internalization of an innovation. The framework is dynamic in nature for two reasons. First, it is extensive enough to provide grounding for several different research streams each consisting of numerous studies. Second and consistent with supply chain operations, the factors are interdependent; thus changes to any individual or combination of variables will have an impact on others.

Dimensions of internalization

Internalization is measured by IT utilization rates, satisfaction, and its capability to perform the desired tasks. In essence, it is a measure of how well a technology is integrated into an organization or supply chain. Because of the various supply chain contexts in which technological innovations are internalized, the factors leading to internalization are varied and complex. These factors are logically categorized, into 12 dimensions based on descriptions and items gleaned from the existing constructs in the literature review. Initial discussions with the 4PL executives yielded three preliminary dimensions associated with internalizing innovations, namely, people, process, and technology. The literature review yielded the proposition that several more dimensions underlie internalization. The final SCIM dimensions and their associated factors were the result of three panels of judges (business academicians, supply chain professionals, and graduate students). The 12 dimensions include issues related to:

(1) technology;
(2) environment;
(3) organization;
(4) individual;
(5) communication;
(6) training;
(7) risk;
(8) trust;
(9) inter-organizational relationships;
(10) organizational roles;
(11) perceived norms; and
(12) demographics.

These dimensions will be helpful in developing a deeper understanding of the components impacting internalization by providing a structure from which to conduct future research.

Conceptually, internalization represents a behavior. As a result, a direct antecedent to a behavior is an intention to behave. For example, before individuals decide whether or not they will internalize a technology they will form an intention to act out that behavior. The same holds true for organizations or supply chains. Through executives or other influential personnel, if these entities (systems) decide to internalize an IT

(intention), only then can it lead to internalization. This would be true whether the decision to internalize is more or less formal in nature.

Table I contains the expanded variable taxonomy of SCIM including the construct definitions and originating theoretical source. Of the various antecedents to predicting internalization, several were consistently mentioned in the primary data collection phase of the study. Specifically, these included innovation complexity, relative advantage, attitude toward technology, perceived usefulness, perceived benefits of the technology, prior similar experience, top management support, and training effectiveness.

Some of the more surprising findings, which did not appear in the literature included procedural loopholes which represented the extent to which users implement procedural deviations to circumvent technological standard operating procedures. This was found to be a consistent roadblock to successful technology internalization in several organizations of varying sizes and geographic locations. Another such finding relates to process experience. In many cases, new processes were implemented in conjunction with the new technology which tended to delay technology internalization, especially if individuals are not introduced to the new process prior to the new technology.

Supply chain specific findings

It should be clear that many of the internalization antecedents are cross-functional in nature and can be applied in a variety of contexts. This is important for SCM because of the many different structural arrangements within supply chains. More specifically to SCM was the finding that individuals' supply chain orientation could have an impact on technology internalization. Several respondents who successfully internalized the technology appeared to have a good understanding of the role of the technology and the importance of providing part-level visibility to the entire supply chain.

Two other antecedents which impact inter-organizational relationships in general but are especially pertinent to SCM are inter-organizational trust and information exchange. Inter-organizational trust represents extent to which one party has confidence in an exchange partner's reliability and integrity. This is a key hurdle that must be passed in order to foster inter-organizational cooperation which includes (in many cases) integrating technologies. Information exchange represents the extent to which parties in the channel relationship actively exchange information that could facilitate business activities. This allows for information sharing (via technology) and may, again, foster more supply chain cooperation. The findings suggest that increased inter-organizational trust and information are not only desirable for successful SCM, but also technology internalization, especially those used to enhance SCM.

Conclusions

The SCIM which resulted from this study is important for several reasons. First, it provides a theoretically and empirically based systematic foundation from which to conduct future research. Using SCIM may enable researchers to take a more consistent approach towards a phenomenon with growing importance, technology internalization.

Although supply chain managers internalized innovations and have been managing supply chains for years, academic research examining the multiple tiers of these systems has lagged. One of the chief reasons for this is that the complexity of the

interrelatedness of the factors associated with the myriad of dimensions of supply chains has thus far precluded such academic pursuits. A GST approach enabled the development of a framework that may be applied from the perspective of multiple tiered focal members of the supply chain.

Second, the research identified factors within SCIM taxonomies to assist researchers in their investigations of those factors pertinent to specific supply chain members including in this case, the buyer, the seller, and the user. The factors may also be applied to multi-tiered members of other supply chains in various organizational settings across diverse industries. Understanding inter-tier antecedents using SCIM will prove valuable to help formulate overall organizational and supply chain strategies.

Future directions for research

Future research directions should include testing the hypothesized relationships established in the SCIM to validate the proposed associations. The present research identifies an extensive set of factors proposed to impact internalization. The relationships outlined in the SCIM should be tested in a diverse array of industries in order to generalize the model. SCIM factors can be compared across supply chains and industries. The relative strength of each factor will vary depending upon the context in which the model is applied. Global sourcing and integrated multinational markets suggest that testing the SCIM from an international standpoint is also warranted. For example, while most individuals will require a modicum of training, the actual quantity, level, and intensity will vary depending upon the potential adopter's attitude toward technology, prior technology knowledge, technological skill level, and trust in the technology. In addition, moderating and mediating effects amongst the variables have yet to be identified. These differences take into account particular variations amongst supply chain members but yet provide the surfeit of possible factors to technology internalization. Empirically testing the proposed directional relationships can be used to confirm their validity and measure the relative strengths of individual or interacting antecedents. SCIM does not address the relative importance of the antecedents in the model; however, using SCIM for future research can also explore factor weights in more detail and in a variety of contextual models.

Because of the theoretical grounding of SCIM, simultaneous multi-tiered empirical testing of these new factors and others found in the literature is possible. This should facilitate supply chain research into internalization at each supply chain level and allows for consistent inter-tier comparisons of antecedent significance. The model's flexibility allows research studies to consider and evaluate the influence of individual or groups of antecedents.

In sum, additional research is necessary to better understand the SCIM factors, and identify those that are most important. Moreover, future research needs to identify the combination of antecedents that have the greatest impact on internalization. By doing so, researchers and practitioners will have much greater insight into which strategies work best when implementing innovative IT within supply chains.

Summary

After an extensive cross functional literature review of factors impacting technology adoption, qualitative data were collected in a series of interviews in a supply chain

context to corroborate the existing literature and extend it to include internalization. Internalization is the effective and consistent use of a technology over time. The research resulted in a framework (SCIM), theoretically based in GST, IDT, and TRA. Because technological changes are rapid and unpredictable, such a framework is useful for practitioners and researchers alike for implementing and understanding how IT is best internalized. The SCIM will assist future research and technology implementation by providing a strong grounding for understanding this phenomenon.

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Appendix: Sample of semi-structured questions

(1) How long have you been using the new technology?

(2) What do you like about using the new technology?

(3) What do you dislike about the new technology?

(4) What are the benefits for using the new technology?

(5) What are some of the problems you encounter with the new technology?
(6) Do you find the new technology easy to use?
(7) Do you find the new technology to be useful?
(8) What are your major job responsibilities?
(9) How much time per week do you spend using the new technology?
(10) What job tasks do you perform using the new technology?
(11) Do you spend more or less time using the new technology to accomplish those tasks than before being introduced to the technology?
(12) Did you have any training in the new technology?
(13) If you had training, did you find it helpful?
(14) Do you understand why the (4PL) or the (automotive) requires you to use the new technology?
(15) Would it be helpful if you knew more about why (the 4PL) or the (automotive company) wanted you to use the new technology?
(16) Did your organization have to purchase any new equipment in order to use the new technology? If so, what needed to be purchased?
(17) Please describe your comfort level with computer technology.
(18) Is there anyone else at your organization who uses the new technology?
(19) What level of education do you have?
(20) Are you a member of a union?
(21) How long have you been in this industry?

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