Applying Transactive Memory to the Supply Chain: A Conceptual View

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ABSTRACT

Knowledge and expertise are critical to proper functioning of supply chains. However, scholars have only stated the need for knowledge and information sharing and overlooked how it conceptually develops in organizations. This research provides an in-depth look at the source of knowledge through the lens of Transactive Memory Systems (TMS). Previous research on TMS has mainly focused on relationships between dyads and within small organizations. This paper extends the TMS literature into the supply chain by applying it through a structure-strategy-performance model. We conclude by reasoning that understanding the theory behind the source of knowledge will enable firms to develop and enhance more efficient supply networks. We also clearly outline how much networks can be developed.

1.1. Introduction

This conceptual research proposes that transactive memory systems (TMSs) are networks of information that facilitate accurate and effective information sharing. These information networks can be especially beneficial when applied to the supply chain. Further, a model of TMS in a supply chain context is developed and applied. Support for the application of TMS in multi-unit, cross-functional teams can be found in the literature (Kotlarsky, van den Hooff, & Houtman, 2012). More recently, supply chain literature introduced TMS as an antecedent to agility and innovation.

This conceptual research addresses a gap in the literature, as scholars have only stated the need for knowledge and information sharing and overlooked how it conceptually develops in organizations. The research provides an in-depth look at the source of knowledge through the lens of Transactive Memory Systems (TMS). Previous research on TMS has mainly focused on relationships between dyads and within small organizations. Recently, literature began introducing TMS to the supply chain as an antecedent of key variables. For example, Fernandez-Giordano, Stevenson,Gutierrez, and Llorens-Montes, J. (2021) found that TMS is an antecedent to supply chain agility while Huo, Haq, and Gu, (2021) found it to be an antecedent to supply chain flexibility which is likely to contribute to ability to respond to supply chain disruptions and innovations. None of these works, while beneficial, did not explain how TMS can be established.

This paper extends the TMS literature into the supply chain by applying it through a structure-strategy-performance model. It also extends supply chain literature by clearly outlining not only the possible strengths of TMS introduction to supply chain but also proposing how it can be developed.

The theoretical basis for this research flows from the Strategy-Structure-Performance paradigm proposed by Defee and Stank (2005). In their model they extend the strategy literature to the supply chain environment to foster a better understanding of the elements characterizing a strategic decision. This research extends their model to the knowledge component term TMS. Knowledge sharing has been described as being important for supply chain success, but there is a gap in terms of what theories would lead to the effective transfer and retention of this knowledge. We propose that extending TMS to the supply chain provides a rich understanding of the theoretical component necessary to foster information and knowledge sharing and continual learning. We term this extension "supply chain transactive memory" (SCTMS).

Properly managed supply chains make important contributions to individual firm performance (Hult, Ketchen, Cavusgil, & Calantone, 2006; Miles & Snow, 2007). This makes them a key subject of study, especially with respect to improving firm performance. Taking into account the importance of supply chains and knowledge sharing, it is no surprise that marketing and management researchers as well as practitioners focus on examining the benefits of information sharing and knowledge networks on a supply chain's performance and variables affecting that performance (Hult, Ketchen, & Slater, 2004; Klein & Rai, 2009; Lee, So, & Tang, 2000). Still, the complexity of modern supply chain systems demands continuous explorations to understand their interdependencies and identify ways to improve supply chain performance.

Knowledge sharing has been shown to be related to organizational performance. Improper knowledge flow may become a hindrance to success (Singh, 2005; Sorenson, Rivkin, & Fleming, 2006). This is likely to be particularly true given the recent supply chain disruptions that reached a global scale. Establishment of structures or networks of knowledge and information sharing that enable organizational learning and task execution become a crucial tool for those practitioners who want to improve an organization's capabilities (Flores, Zheng, Rau, & Thomas, 2012). Knowledge structures may enable reaching higher levels of effectiveness and efficiency, which cannot be underestimated especially from a perspective of meeting task or project related objectives and deadlines by the working team (Akgun, Byrne, Keskin, Lynn, & Imamoglu, 2005; Xue, She,& Ren, 2010). Additionally, they may help improve speed of responsiveness to threats to prevent delays and improve effectiveness. As we became aware over the last two years, these qualities were potentially critical in face of recent Covid-19 related disruptions. Further, they may play a critical role in the future, inadvertently coming disruptions as related to the war in Ukraine

The relationship between knowledge development and sharing has a positive effect on organizational performance (Hult, Ketchen, & Arrfelt, 2007). This paper looks at how information and knowledge can be shared while simultaneously reducing cognitive load on individuals within organizations in a supply chain by introducing TMS. Practitioners can improve the supply chain's effectiveness and increase organizational performance through a greater access to knowledge and information sharing. Lewis and Herndon (2011) specifically state that "TMS provides an ideal—albeit underutilized—lens through which to consider the performance and development of groups engaged in complex, dynamic tasks" (p. 1262). It is argued here that the same can be done in a supply chain environment, which is known for its complexity. Finally, we define a Supply Chain Transactive Memory System (SCTMS) as the summation of individual memory systems communicated through task experts. This takes place between individuals at the boundaries of a firm and leads to increased information sharing and knowledge sharing, thus creating inter-organizational learning which benefits each firms' performance. Now that we have introduced TMS and SCTMS, a review of the TMS literature is provided followed by a discussion of the value of TMS as a conceptual tool for increasing information sharing in the supply chain.

1.2. Literature Review

1.2.1 Transactive Memory System(s) (TMS)

1.2.2. Defined

A transactive memory system (TMS) is in essence, the reliance on experts' knowledge for task execution (Ren & Argote, 2011). It is a form of a knowledge network originating from a psychology research perspective (Phelps, Heidl & Wadhwa, 2012). TMS is viewed as a type of socially shared cognition, but what makes TMS unique from other forms of socially shared cognition are three features that include "(1) differentiated knowledge; (2) transactive encoding, storage, and retrieval processes; and (3) the dynamic nature of TMS functioning" (Lewis & Herndon, 2011, p.1255).

TMS can also be viewed as a structure of cognitive interdependence among group members where group members rely on one another to take responsibility for storing information and where retrieval is enabled (Hollingshead, 2001). A well-developed TMS relies on networks of experts within their fields (Austin 2003; Hollingshead, 1998). These networks should be easily accessible by non-experts within a group in order to promote the best and most efficient completion of a task or project. A non-expert within one area may be an expert within another area. When all group members are aware of each other‘s expertise, TMS works at its best (Austin, 2003). This means that there are no misconceptions about who holds the expertise within a certain area. If no misconceptions of member expertise are present, a high degree of transactive memory exists. According to Lewis, Lange, and Gillis, (2005), a TMS helps to solve the task at hand as well as enhancing understanding of the task domain. Based on the above it can be concluded that a TMS is a connected network of transactive memory networks (network of networks).

A number of studies found that a high level of transactive memory within a firm increases performance and the organization's dynamic capabilities (e.g. Austin, 2003; Argote & Ren, 2012; Liang, Moreland & Argote, 1995; Lewis, 2004; Moreland, 2006). What follows is a development of the TMS network.

1.2.3. Basis for TMS Network.

1.2.3.1. Development of individual memory (IM).

Individual memory (IM) is an antecedent to TMS development. Individual memory systems in the system can be viewed in two ways. First, within a firm, a single individual possesses a single memory on which other individuals can rely. The individual at some point became an expert when s/he accumulated enough in-depth knowledge within her/his individual memory. Members of the group became aware of this expertise during interactions (Peltokorpi, 2012). Each firm consists of a number of individuals with individual memories. These individual memories are then shared among the firm members, which then create a memory system within this particular firm (Austin, 2003; Brandon & Hollingshead, 2004). In this case, the firm becomes a

TMS. Within this system, an individual with specialized expertise becomes a location of information for those who are not experts (e.g. Hollingshead, 1998; Wegner, 1987). This individual possesses an individual memory (IM) in a TMS at a firm level.

1.2.3.2. *Development of Task-Expertise-Person (TEP).*

Once TMS is developed and team members become aware of the cognitive interdependence between the individuals, a second cycle of TMS development can take place. During the second cycle, group members begin to associate people, their expertise and knowledge the experts can offer with the task that is to be solved or a project to be completed (Brandon and Hollingshead 2004; Lewis, & Gillis, 2005). Brandon and Hollingshead (2004) proposed another structure of TMS advancing the understanding of how the system works by introducing task-expertise-person (TEP) units. TEP is viewed as a dynamic structure because the group's perceptions of the associations between task, expertise and person can change over time. TMS not only depends on linking expertise with an individual but also on how well the knowledge fits the task's needs (Akgun, Byrne, Keskin, Lynn, & Imamoglu, 2005; Brandon & Hollingshead, 2004; Lewis, 2004). Tasks need to be divided in such a manner that the TEP can function. However, it has to be noted that TMS should not be only used for a specific task solution, but instead to open an opportunity for a broader use across task domains (Lewis, Lange & Gillis, 2005; Peltokorpi, 2012).

1.2.3.3. Three Stage Process of Transactive Memory Systems Development

Previous researchers have stated that TMS development take place during a three-stage process that involves encoding, storage and retrieval (Hollingshead, 1998; Lewis, Lange & Gillis, 2005; Wegner, 1987). The first stage, *encoding of information*, is a stage during which information is encountered and assigned a naming property, otherwise known as labeling. The labeling is not only associated with providing a naming category to the information encountered but also linking it to the correct expert. For example, an individual may, during a supplier meeting, discuss and define a number of complex components that the organization has to offer. Each component receives its specific name (either catalog name or a commonly used abbreviation) under a broad category of “components” and is linked to the individual who has knowledgably discussed these components. The second stage takes place and is referred to as the *storage stage* during which the newly encoded information is stored in either internal or external memory otherwise known as location. The internal memory is the storage in one’s memory (i.e. brain) while the external location is outside of one’s memory. The external location may be a computer memory, calendar, notebook, etc. The members become locations of external storage for each other (Austin, 2003; Hollingshead, 1998; Lewis, 2003; Lewis & Herndon, 2011; Wegner, 1987; Wegner, 1995). A group member may choose to learn the in-depth information about components or he/she may choose to rely on the expert when the information about components is needed. As noted earlier, during group discussions, the exchange of information among members takes place (Hollingshead, 1998). When these interactions take place, any misconceptions about the identity of actual experts within a field should be clarified (Austin, 2003; Hollingshead, 1998, Peltokorpi, 2008). Should the individual who discussed components have not been a true expert, this possible misconception needed to be clarified during a meeting. Brandon and Hollingshead (2004) suggest that over time, knowledge becomes specialized among members and different members can carry different knowledge responsibilities.

Finally, the third stage is the *retrieval stage* during which the information is recalled from memory when needed. Again, the retrieval can take place from either an internal or external location (Moreland, Argote & Krishnan, 1996). TMS, however, develop when an external location is another individual. Shared, working experience between individuals foster development of TMS while differentiation of knowledge allows members to be responsible for unique knowledge (Lewis, 2004; Lewis & Herndon, 2011; Moreland & Argote, 2003, Zheng, 2012).

1.2.4. Value of TMS

1.2.4.1. *Reduces cognitive load.*

The literature on cognitive load theory establishes that individuals can process only a limited amount of new information (e.g. Miller, 1956; Sweller & Chandler, 1991). Once too much information is encountered, attempts at learning additional information result in increased error (Sweller & Chandler, 1991). Because of the complexity and diversity of tasks, individuals are more likely to encounter tasks that require information outside their own area of expertise. What adds to the complexity is the need for tasks to be completed under time pressures, which, according to the cognitive load theory, is likely to lead to an increased rate of error.

Wegner (1987), Hollingshead (2001) and Austin (2003) specifically state that specialization diminishes cognitive load on an individual. Furthermore, a group of experts with specialized knowledge, each of whom had direct interactions while working together on a task or project, is more likely to be more creative as a team than those teams without direct interaction (Gino, Argote, Miron-Spektor & Todorova, 2010). Therefore, TMS can be viewed as a tool that enables effective information sharing and allows the cognitive load to be diminished.

1.2.4.2. *Increases organizational communication.*

For the memory to become transactive, communication needs to occur (Hollingshead & Brandon, 2003; Kotlarsky, van den Hooff & Houtman, 2012; Liao, Jimmieson, O'Brien & Restubog, 2012). The exchange of information between members' internal and external memories and the impact it makes on individual decisionmaking is what makes it transactive. Communication, especially face-to-face communication, fosters development of TMS and triggers retrieval (Lewis, 2004).

Communication is crucial for TMS to work effectively and accurately, (Hollingshead, 1998; Kotlarsky, van den Hooff & Houtman, 2012). Hollingshead (1998) notes that communication is a "medium for transferring information from one individual to another (…) by which individuals can learn about the knowledge, expertise, and relevant experiences of other individuals in the system" (p. 427).

Studies suggest that not only the quantity of communication but also the quality of communication plays a key role in TMS development (Kotlarsky, van den Hooff & Houtman, 2012). The importance of communication is especially highlighted in the encoding and storage stage, where the label and location are assigned. When the location is assigned, individuals become aware of who holds the expertise (Lewis, Lange, & Gillis, 2005). In this situation, transactive memory becomes an ongoing group structure that can be advantageous for the tasks at hand during day-to-day business, special projects and any future endeavors.

Therefore, a TMS may be used in a much broader sense than for a single and specific task execution. Exhibit 1 summarizes our discussion of the theoretical framework for TMS. Individual memory (IM) is an antecedent to TMS (which is composed of three stages). Once TMS develops there is a second cycle which is the identification of the task expert person (TEP) who possesses the knowledge to meet the demands of the task(s) at hand. This process benefits the organization by reducing cognitive load and increased communications.

INSERT FIGURE 1 ABOUT HERE

1.2.5. Extending Transactive Memory Systems to the Supply Chain Context

The extant literature has focused mainly on the functioning and advantages of TMS within interpersonal relationships, internal groups and small organizations (Austin, 2003; Gupta & Hollingshead, 2010; Hollingshead, 1998; Hollingshead, 2001; Moreland, 2006; Peltokorpi, 2008; Peltokorpi, 2012; Ren & Argote, 2011). Within the TMS literature only one study briefly mentions that TMS has the potential to be developed on a multi-organizational scale between interconnected firms that cooperate on a network level (Ren & Argote. 2011).

Supply chains require ever increasing communication demands which necessitate constant information sharing. This means supply chains are a fertile new area for the development of a TMS. By introducing TMS in supply chains, the benefits of TMS can be expanded to inter-organizational networks and increase organizational capabilities and performance.

TMS allows for access to an extensive knowledge pool without increasing cognitive demands on an individual lacking the necessary expertise (Austin, 2003; Hollingshead, 2001; Zheng, 2012). As a result, a type of dependence on experts is created that allows for greater team efficiency and effectiveness. With their greater member integration and greater synchronization of activities, supply chains require expertise both within and outside the organization's boundaries allowing TMS to be applied in a supply chain context.

For the purpose of this study, we rely on the definitions adopted from Mentzer et al. (2001) as well as Choi and Krause (2006), who view the supply chain as a network of suppliers, distributors and customers that use upstream and downstream communication and information exchange between the focal firm and their constituents. This exchange is influenced by the quality of inter-organizational connectedness, which then allows better knowledge sharing. The overall goal is to increase performance through open lines of communication and information sharing within the organization and outside those organizational boundaries. Supply chain specific studies support this claim by emphasizing that collaboration between supply chain participants leads to increased performance due to increased ability to satisfy customer needs at lower cost (Fawcett, Wallin, Allred & Magnan, 2009; Hult, Ketchen, Cavusgil, & Calantone, 2006).

From a TMS perspective, dissemination of knowledge-about-knowledge needs to take place before the TMS can effectively work (Moreland, 2006; Peltokorpi, 2012). Thus, every active entity of the supply chain needs to be aware of who holds expertise within each particular area. On a *macro level*, each participating firm needs to be aware of each other's expertise, while on a *micro level*, each individual within each organization needs to be aware of experts within their own firm, as well as those of their suppliers and customers. This process then creates a TMS system of knowledge.

Improving supply chain efficiency and effectiveness generates value for customers (Morash & Clinton, 1998). TMS may prove beneficial to several levels of the entire supply chain and, ultimately, the customer. First, it has been suggested that organizations that create alliances of firms who voluntarily form networks of support and attempt to optimize them, should consider not only firm, but also alliance level optimization especially with regard to decision-making (Walter, Kellermanns & Lechner, 2012). Thus, formation of structures such as TMS within a firm and its network for the optimization of the entire network has it support in the literature. Second, TMS applied to supply chain can be beneficial because one of the issues concerning solving problems, executing tasks or working on new projects in chains of organizations is that these tasks may be highly complex and differentiated and extend beyond a single person's expertise. Individuals who attempt to learn new information to expand their expertise in order to execute tasks are likely to face problems related to cognitive load and the brain's limited capacity (Schnotz & Kurschner, 2007).

1.2.5.1 Knowledge Sharing and Collaborative Relationships

While there is currently no direct application of TMS in the supply chain, writers have proposed concepts that would apply to a TMS model. These include knowledge sharing and collaborative relationships.

1.2.5.2. Knowledge Sharing

While information sharing can lead to increased knowledge in TMS, knowledge sharing is often more complex than simple information exchanges because it involves "the exchange of know-how, and feedback with customers, organizational experts, and others outside the group," (Cummings, 2004, p. 352). Unlike information, knowledge begins with experience, which makes it difficult not only to share, but also to acquire by those without related experience (Argote & Miron-Spektor, 2011). What makes knowledge so important is its link to performance, thus making it a fundamental concept for understanding and managing organizations (Brauner & Becker, 2001). Overall, knowledge is more intricate and more difficult to transfer while information itself is only a subset of knowledge. Thus knowledge sharing in supply chains can be judged similar to internal organizational sharing that characterizes TMS systems.

Knowledge sharing works best in well-defined knowledge networks. Knowledge networks consist of nodes or clusters of individuals that "serve as heterogeneously distributed repositories of knowledge and agents that search for, transmit, and create knowledge—interconnected by social relationships that enable and constrain nodes' efforts to acquire, transfer and create knowledge" (Phelps, Heidl & Wadhwa, 2012).

Collaborative knowledge networks are important in the sense that they allow for the knowledge to disseminate between the members (Singh, 2005). Researchers note a need for improving knowledge sharing and the structure of knowledge networks (e.g., Bartol & Srivastava, 2002; Brauner & Becker, 2001; Hansen, 2002).

However, a missing link exists between knowledge development and its management within groups (Phelps, Heidl & Wadhwa, 2012). For example, sharing demand information among the members of the supply chain not only reduces demand distortion (Lee, Padmanabhan, & Whang, 1997), but also can lead to more accurate demand forecasts, increased capacity utilization, optimal inventory levels, and better customer service (Lee, So & Tang, 2000).

1.2.5.3 Collaborative Relationships

With respect to the supply chain and on a broad level, the process of information and knowledge sharing needs to take place through participation and collaboration of all entities involved in a supply chain, rather than single departments within a particular organization alone. It should be noted that communication of knowledge is especially difficult for cross-functional teams that are highly differentiated (Kotlarsky, van den Hooff & Houtman, 2012). As previously stated, information and knowledge sharing are crucial elements of transactive memory. However, if any involved entity does not see the benefit of TMS development or is unwilling to participate, an effective and accurate TMS within a supply chain is unlikely to develop.

Collaborative relationships between supply chain partners that include information sharing, among others, not only increase efficiency and sustainable competitive advantage, but also foster trust and commitment between the participating entities (Nyaga, Whipple, & Lynch, 2010). Therefore, it can be inferred that information and knowledge sharing at the supply-chain level is the process of knowledge about markets and customers across multiple organizations.

As an example, the leadership at Under Armour stated that supply chain collaboration was going to be a core competence at Under Armour, referring to both internal and external collaboration. Under Armour had $2.3 billion in sales in 2013, and expects to grow another 22% in 2014, on its way to being a $10 billion company by 2020. Since it went public in 2005, it has had a cumulative annual growth rate of 31%. Under Armour’s formula for growth was to be fast (speed) and innovative. Their strategy was that growth was the multiplicative outcome of these two variables. Extending this model to the supply chain required adding two variables. Supply chain growth required speed but this speed needed both predictability and control. (Gilmore, 2014) Achieving speed with predictability and control requires that the TEP in both firms develop TMS across organizational boundaries.

We depict this in borders that will require extensive collaboration in the supply chain. This is shown in Figure 2 below. As is illustrated in Figure 2, the individual firm's TMS (supplier TMS and customer TMS) meet at the boundaries of the organization to create a collaborative TMS. These cross-organizational interactions are carried out by different TEPs at both the customer or supplier sides depending on the task required of the supply chain. For example, if it is solving a quality problem then the supplier's quality engineer personnel will meet with the customer's design team. Alternatively, if it is a discussion about the price of a product or service the TEPs will be the purchasing agent and the marketing manager. Through these interactions a joint SCTMS is developed and the TEPs increase their individual memories (IM) leading to enhanced TMS at both the supplier and customer firms. Thus Figure 3 shows that the SCTMS equals the sum of the TMS at the focal firm plus the TMS of the customers and or suppliers. Depending on the complexity of the supply chain network both upstream and downstream, the SCTMS could be quite substantial and involve many TEPs.

INSERT FIGURES 2 & 3 ABOUT HERE

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1.3. Model Development

Beeby and Booth (2000) extend the model of organizational learning as an inter-level process developed by Rashford and Coghlan (1994). The framework identifies four levels (individual, team, interdepartmental group and organizational) within and between which learning and unlearning take place. They argue that this framework requires modification to reflect the increasing incidence of co-operative relationships between organizations, and the need for knowledge acquisition and integration within such relationships. They propose the incorporation of an additional inter-organizational level of aggregation at which it is also meaningful to speak of productive organizational learning (Beeby & Booth, 2000).

Knowledge sharing has been described as being important for supply chain success, but there is a gap in terms of what theories would lead to the effective transfer and retention of this knowledge. We propose that extending TMS to the supply chain provides a rich understanding of the theoretical component necessary to foster open knowledge sharing and continual learning. We further propose that increased knowledge sharing and properly aligning these important elements will increase collaborative inter-organizational learning, leading to improved inter-firm performance. A model based on the work of Defee and Stank (2005) was used to apply TMS to the supply chain. Their framework shows an iterative relationship between strategy, structure, and performance measurement systems. Their model implies that a company's supply chain strategy should be complementary with that of supply chain partners. It also identifies the elements comprising a supply chain structure required to support supply chain strategy implementation. These elements included technology integration, communication, standardization, decision-making location, and reward and compensation programs.

Further, Defee and Stank (2005) extend the strategy literature to the supply chain environment to foster a better understanding of the elements characterizing a strategic decision. We extend the structural aspect of this model to TMS in the supply chain. We term this extension of TMS as supply chain transactive memory system (SCTMS). SCTMS is the summation of individual memory systems communicated through a task expert that takes place between individuals at the boundaries of a firm and leading to increased information and knowledge sharing, creating collaborative inter-organizational learning benefiting each firm's performance.

Figure 4 illustrates the application of the SCTMS Structure Strategy Performance Model. Our model extends Defee and Stank's model by adding a TMS perspective and introducing SCTMS to encompass the interactions that occur when organizations interact. All of the variables that were previously discussed in this research are presented. They include: information, information sharing, knowledge, knowledge sharing, collaborative learning, TEPs and TMS. The intent of the model is to illustrate how SCTMS can enhance interfirm performance. While previous literature acknowledged these variables, we demonstrate a framework that allows them to flourish.

Finally, from a risk perspective cognitive load theory relies on a premise that individuals can learn only limited amounts of new information. Once too much information is encountered, attempts at learning additional information result in increased error (Sweller & Chandler, 1991). Organizations within supply chains frequently require information related to another organization's area of expertise. If this exceeds the expertise of the parties' capabilities it could expose the entire organization to risk of error. A recent example of this is the General Motors discovery of defective ignition switches. Does the blame for the defect fall on the focal firm General Motors because of a faulty design or its supplier due to defective switches (Bennett, 2014). In either case, the SCTMS was not great enough to avoid the problem or the expertise necessary to solve it (TEP) was not located. Our model proposes that increased knowledge and information sharing will reduce risk of error and thus allow the supply chain to be more effective and efficient. Next we will trace SCTMS development through the previously mentioned steps of TMS development.

INSERT FIGURE 4 ABOUT HERE

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1.4. Stages of Supply Chain Transactive Memory System Development

1.4.1. Labeling

Relying on the literature reviewed, it is suggested that whether from a single firm TMS or SCTMS perspective, individual units, which here are either the group members on an individual firm level or individual firms if looked at from a supply-chain perspective, develop a 'hierarchical set of labels' in order to enable themselves access to individuals and promote joint task responsiveness. This is the encoding stage of TMS. Labeling is a complex step for three main reasons. First, it is critical that the correct label is assigned; otherwise, mislabeled information may be hard to retrieve in later steps. Secondly, information needs to be assigned a broader category which leads to hierarchical labeling. Thirdly, an individual that apparently voices his/her expertise has to have the capability to claim the area of expertise. In other words, an individual must be a true expert. For example, eleven years ago, when P&G's products offerings expanded rapidly, the company's intense focus on in-store sales and price promotions played havoc with product demand. This caused short-term, marketing-induced spikes in demand. As a result, P&G spent millions on increasing manufacturing capacities, inventories, warehouses, and logistics to keep up with fluctuating demand (Sims, 2013). In its efforts to make improvements, P&G modified its supply chain focus, both internally and with suppliers and customers, more closely tying their marketing to production, inventories, and logistics in response to changing business requirements (Sims, 2013). From a SCTMS perspective, the P&G success could be associated with a well run system that began with proper hierarchical labeling. For example, price promotion could have been one of the broad domains and labeled as such. From there, narrower categories could be assigned to each task or information related to the category such as competitive price matching, quantity discounts, coupons, etc. With that, an individual was assigned to each broad domain or, more narrowly, each category. The more complex is the domain, the more nested the hierarchy of labeled information becomes. Each member knows who is responsible for which domain or category which allows for easy access to that domain or category though proper localization of an expert. Therefore, when one wanted to gain access to P&G price promotion specific information, this domain specific information could have been easily obtained by accessing a domain specific expert. Therefore, after a label is assigned to domain/category specific information, an assignment of location can take place. An expert is the location for localization of domain specific information.

1.4.2. Location

After the labels are developed, the estimation of a task's parameters takes place and is followed by decision making about the kind of resources necessary to execute the task. This is the "what, how and who" of the task execution. Between the development of the labels and the decision-making about "what" (the task), "who" (the expert) and "how" (the necessary resources) a connecting link is necessary. The best way to establish the expertise mentioned above is by group interaction and, therefore, by the use of communication between the individuals within an organization (Hollingshead, 1998; Hollingshead & Brandon, 2003; Kotlarsky, van den Hooff & Houtman, 2012). This stage aligns with the "stored" stage of TMS.

One example of this is the use by many firms of a Warehouse Management System (WMS). Usually it consists of a group of computer programs designed to help a manufacturer or distributor perform their warehouse operations faster and with fewer errors. WMS systems improve customer service and resource utilization in terms of inventory, buildings, and people (Muehlbauer, Nd). As previously discussed in the P&G example, when a group member wanted to access price promotion related information, s/he could easily access that information if s/he was aware where the information could be located. As previously mentioned, in TMS, another human is the location of information, hence, a domain specific expert. This is true regardless of whether the group member who has the need to access the information is the member of P&G or a member of Walmart.

1.4.3. Retrieval

The expert provides the resources, which in the case of TMS is the task specific knowledge (Hollingshead, 2001) which is the "retrieval" stage of TMS. Each expert, whether at the single organization level or multi-organizational (supply chain) level, can be a part of the task-expertise-person (TEP) unit. In TEP units, depending on a task, expertise is associated with a person (Brandon & Hollingshead, 2004). Expertise is assigned on an individual or organization level. Austin (2003) as well as Brandon and Hollingshead (2004) suggest that for the TMS to work at high levels, a task must be accurately assessed. Here, it is proposed that the TEP can also exist within the supply chain context. In a supply chain, depending on the task, a specific firm within the supply base is assumed to have expertise in an area required to complete the specific task. Once the expertise is assigned to a company, the focal company can retrieve information necessary to execute a task from the company holding the expertise. Again using P&G as an example through its partnership with Walmart, the representative for P&G is stationed at Walmart headquarters in Arkansas and places orders for P&G products based on Walmart's daily sales. These orders replenish stock that is leaving Walmart's distribution centers and bound for customers. Thus firms have made retrieval easier by locating a TEP on site (Sims, 2013).

1.5. Research propositions

Applying this new conceptual model (SCTMS) to the supply chain leads to four research propositions that are based on aforementioned conditions for effective supply chains. This was done for two reasons, first, to anchor SCTMS into the existing literature and second, to provide a framework for future researchers to extend this conceptual work.

1.5.1. Task Expertise Person (TEP) in an SCTMS Model

The highest levels of TMS take place within groups that have direct interaction and task experience and are stable over time as opposed to those that frequently change members (Gino, Argote, Miron-Spektor & Todorova, 2010). Brandon and Hollingshead (2004) state that for TMS to be efficient, TEP also needs to develop. In this paper, it is argued that for a firm to have high levels of TMS, multiple TEP units need to develop. Based on the above, it is proposed that for SCTMS to develop Tier I firms need to develop TEPs. With that, the retrieval takes place using label and location. Then, when a task is encountered, it can be assessed in a way that it becomes clear under which expertise area it falls. Knowing where the expertise resides (hierarchical labeling and location assignment), allows supply chain members to properly assign information to the expert.

The validation of information has been previously described as encoding of information (Wegner, 1987; Hollingshead, 1998). According to Wegner (1987), "individuals are seen as linked to knowledge on the basis of their personal expertise, or through the circumstantial knowledge responsibility that accrues as a result of how the knowledge has been encountered by the group" (p. 192). Based on the literature, logic and previous discussion of Figure 4, proposition one follows.

Proposition 1: To develop a SCTMS, each entity within the supply chain must develop multiple TEPs within their organization, and collectively or individually interface with other TEPs outside the boundaries of the organization.

1.5.2. Improving TEP Matching

Intra and inter-organizational interaction and communication are essential in achieving flexibility, responsiveness and competitiveness in a supply chain context (Gunasekaran & Ngai, 2004). Information and knowledge sharing through a process of interaction and communication allow an organization to perform tasks faster and more effectively, as it has an access to wide range of knowledge within a group. Knowledge sharing in an SCTMS model are enhanced by properly matching those knowledge entities on each side of the supply chain dyad. According to Austin (2003) and Brandon and Hollingshead (2004), development of an effective TMS does not only rely on the interaction between the entities. The information exchanged during the interaction needs to be accurately assigned, so that the experts are assigned by their particular areas of expertise, which, in turn, can be used for solving a task. Thus better matching of the TEPs at both organizations will increase the timeliness and accuracy of information exchanged across an SCTMS system.

As previously mentioned, TMS relies heavily on how members perceive each other's knowledge (Hollingshead, 2001). Only a precise perception of the knowledge can lead to the distribution of knowledge responsibilities. Extending this to the supply chain means that this precise recognition of knowledge and knowledge responsibilities within a group is referred to as accuracy, and, necessary for effective SCTMS. Only accurate representation of expertise within an organization can allow for the high levels of TMS to occur. Wegner (1987) emphasizes interaction as necessary for accurate TMS development. He suggests that knowledge recognition and responsibility for knowledge among members should not be left to chance. Thus it is critical for inter-organizational communication that the TEPs on both sides of the supply chain dyad are clearly identified, matched and allowed to interface freely. This leads to Propositions 2.

Proposition 2: Organizational structures that enable increased visibility for their task expertise personnel (TEPs) will permit more efficient sharing of information and knowledge in SCTMS systems.

1.5.3. Collaborative Inter-Organizational Learning

It follows from proposition two that firms who value the results from better matching of their TEPs will experience higher levels of SCTMS. The frequent inter-organizational interaction of these TEPs will lead to increased collaboration. This collaboration results in increased inter-organizational learning. Organizational learning is a function of two related but different concepts. These two concepts are the process of learning and the structure of the learning organization. Organizational learning is the development of new knowledge or insights that have the potential to influence behavior (Slater & Narver, 1995). The learning organization is an organization skilled at creating, acquiring, and transferring knowledge then modifying behavior to reflect this new knowledge (Garvin, 1993). Organizational learning has been studied from a high level supply chain and at a strategic level (Hult, Ketchen, and Nichols, 2003). These researchers suggest that learning is a composite construct composed of learning, systems, team, and memory orientations. However, none of this research looks at the method of transferring this knowledge. We propose that the increased interaction of these TEPs inter-organizational learning at the boundaries of the organization improves inter-firm performance.

Firms that better match their TEPs across boundaries will learn from each other and gain interorganizational knowledge that can create an environment improving the performance of both firms. While we have focused our research on the tier one supplier, it is logical to assume this improvement can be extended to multiple tiers of the supply chain. Thus we make our third proposition.

Proposition 3: Better matched TEPs on both sides of the dyad will lead to increases in collaborative interorganizational learning and increased inter-firm performance through improved efficiencies.

1.5.4. Cognitive Load and SCTMS

A TMS is most effective when its members can accurately specify the experts (Brandon & Hollingshead, 2004). When an accurate task assessment and accurate specification of task are present, an individual, using previously learned schemata, may approach task attainment without increased cognitive load. An accurate recognition of the types of knowledge necessary for task solution and effective project work allows the members of the systems to access a greater pool of knowledge. The dissemination of information within an organization allows for organizational learning and strengthening of TMS, while lowering cognitive load on those without the expertise.

It should be noted, however, that in situations where an individual is repeatedly exposed to the same information, this individual learns the new information even if pieces of old information are replaced with new information (Ben-David, Campeanu, Tremblay & Alain, 2010; Cook, 1994; Wogan & Waters, 1959). Hence, the individual is not only able to access a larger pool of knowledge due to the network character of TMS but also, over time, learn new information while reducing cognitive load. In SCTMS, knowledge becomes objectified and easily retrieved when needed (Kotlarsky, van den Hooff & Houtman, 2012). On the other hand internal cross-functional teams face challenges related to knowledge flows from knowledge differentiation and integration (Liao, Jimmieson, O'Brien, & Restubog, 2012; Majchrzak, More, & Faraj, 2012; Oborn & Dawson, 2010). Therefore, from a supply chain perspective, it is logical to assume that as the network of firms in the chain expands, so does the scope of information to which individuals are exposed. Correspondingly, if the right TEPs are not identified and interfacing across the supply chain the likelihood is higher that demands on individuals exceed their cognitive capabilities. This is especially true because the supply chain can also be viewed as an extended and hierarchical network of firms, within which the focal firm and its direct suppliers (Tier I) and their suppliers (Tier II) are included in an extended supply base (Choi & Krause, 2006). Exceeding cognitive load on a SCTMS is likely to lead to more errors and higher risk. This risk can lead to supply disruptions and have a detrimental effect depending on the probability and magnitude of the risk. (Zsidisin & Smith, 2005)

If the information shared by the TEPs proves to be accurate and valid, the cognitive load on the supply chain is manageable performance attainable. Conversely poorly matched TEPs will produce a situation where the organizations' cognitive load is exceeded leading to potential errors and risk of supply disruption. This leads to proposition four (a) and four (b):

Proposition 4a: Improved matching of TEPs across the supply chain leads to a reduction in cognitive load on the inter-firm interactions and leads to higher levels of SCTMS.

Proposition 4b: Mismatching of TEPs across the supply chain leads to an increase in cognitive load on the inter-firm interactions and lower levels of SCTMS.

1.6. Conclusions

Researchers agree that information, knowledge sharing and collaboration are necessary for enhanced supply chain performance. However, they have neglected to conceptualize how the transmittal of this knowledge occurs across the supply chain. This research proposes that this transmittal can be viewed through the lens of TMS and TEPs ultimately forming a supply chain (SCTMS). The research particularly focusses on the role of the TEP on each side of the dyad and proposes that the way organizations match their TEPs in a supply chain context will affect the level of SCTMS that the firm achieves as well as reducing the cognitive load on the entire system. Specifically, this paper develops SCTMS as an information intensive and collaborative inter-organizational process among supply chain members. A highly valued advantage of SCTMS is its capability to lower cognitive load on individuals at the boundaries of the organization. Cognitive load theory focuses on limitations that each individual faces when working on a new, complex task. Reduction of this type of cognitive load allows individuals to process new information without errors and to learn ways of solving a problem or executing a complex task.

In this paper, a model of SCTMS development is proposed while also providing insights into antecedents of effective TMS. Employees involved in day-to-day business and even team members collaborating on special projects may eventually acquire some of the knowledge that the experts hold. This knowledge, however, is most likely not going to reach the levels of in-depth knowledge an expert possesses.

The newly acquired knowledge by non-experts would not be sufficient to replace the expert. Therefore, it is crucial that members have differentiated, non-overlapping expertise so that each member has a large pool of knowledge to access by relying on expert members. Consequently, in a supply chain, individual firms may have differentiated, non-overlapping expertise. This matching of TEPs across organizational boundaries can be improved by organizations permitting increased visibility into their systems.

In this paper, the authors claim that TMS can be used to improve problem-solving effectiveness not only in a single organization or in a dyadic relationship as it has been suggested before, but also within a supply chain context. Both academicians and practitioners could benefit from the development and further research of SCTMS as an information transference mechanism. The validity of this proposition is embedded in research based assumption that TMS are likely to be an excellent way to increase organizational efficiency through effective problem solving and as a knowledge management tool.

Relying on existing literature, it has been proposed that the increased efficiency and complex task solving capabilities can take place when high levels of knowledge and information flow are enabled through the networks of expertise. Furthermore, a level of knowledge differentiation between the system's members must be present in order for different experts to emerge. These different features are the key aspects of SCTMS, which, in turn, make complex tasks and projects more manageable and enable their successful and timely completion without increasing cognitive load on individuals.

High levels of SCTMS should lead to enhancement of the overall TMS of the focal firm. Ongoing interaction between supply chain members ought to optimize an overall SCTMS of the focal firm through increased accuracy and retrieval of information in the supply chain system while careful selection and monitoring of a manageable size supply base ought to elevate information accuracy of the TMS in the overall supply chain both on organization's and entire supply chain level.

Furthermore, the authors proposed a visual model of how up and downstream flow of product/services/knowledge works in a TMS within a supply chain network. The antecedents of an effective and accurate TMS are interactions and communication among members, information sharing among the active entities, task and knowledge specialization as well as shared representations of the networks of expertise.

1.6.1. Managerial Implications

Supply chains by their very nature trigger complexity and therefore require that both strategic and tactical tasks be managed in a timely, effective and accurate manner. This is especially true since the individual firms who comprise the supply chain are profit seeking entities that often have competing goals. Further, recent supply chain disruptions on a global scale taught us that more needs to be done to supply chain members to quickly respond to threats. Given these situations, there is a need to understand the process that occurs in organizations to transfer knowledge. If TEPs can be identified on each side of the dyad, these interfacing organizations can begin to address common goals leading to more effective supply chains. First, it is incumbent on the manager to discover the pools of knowledge that exist in their organizations and then identify the specific individuals who possess this knowledge. In building SCTMS, managers, in their respective firms must first seek to identify these key individuals. Identification may be based on the type of position such as purchasing and marketing both of which are boundary spanners. Alternatively, it could be a key individual in the buying center such as an engineer, maintenance supervisor, or production planning manager. It is crucial to identify these key internal stakeholders who are a part of the buying center. These individuals will collectively develop TMS internally.

Managers must recognize that internal TMS is only 50% of the total equation. As we saw in the Under Armour example earlier, internally the firm desired both speed and innovativeness that required a certain level of TMS. However, moving this to the supply chain required adding two additional variables of predictability and control. In Under Armour's case, at the intersection of the firm's boundaries, the SCTMS will include the internal TMS plus these two other important variables. At Under Armour, it would behoove managers to include in their supplier selection criteria an evaluation of the potential supplier's technology and their delivery and capacity capabilities to insure this predictability. The supplier's internal TMS should be able to exhibit a high degree of control over its internal operations particularly as they affect customers. This matching of Under Armours' requirements with those of the perspective supplier should insure a higher level of SCTMS. To be effective, the interactions should be made via an open system on both sides as this increases the chances of properly matching the TEPs.

Past researchers have studied the dimensions of accuracy and confidence in knowledge and postulated that firms would increase performance by increasing the accuracy of information (Pillai, 2010). We agree and would encourage managers to realize that the accuracy of their individual TMS is cumulative in an SCTMS model. While calibration of SCTMS is beyond the scope of this paper, we would speculate there would be synergistic effects in SCTMS. These synergistic effects would result in the collaborative inter-organizational learning that is part of our model. Managers can begin to calibrate the effects of inter-organizational learning through the establishment and evaluation of joint goals, such as total supply chain inventory levels, supplier responsiveness to emergencies, innovation in process redesign, etc.

As previously mentioned, support for collaborative inter-organizational learning was achieved through the P&G and Walmart arrangement that allowed P&G to greatly reduce price promotions allowing increased predictability and control over demand. This one example illustrates to managers at these two organizations that their SCTMS is working.

Managers also need to understand that it is not enough to identify the experts and transfer the knowledge. In true SCTMS, this knowledge must be transferred not only efficiently and accurately but build a sense of confidence that the information will be utilized appropriately. For example, just transmitting a forecast says nothing about the accuracy or confidence that the transmitting party has in the forecast. If the customer frequently changes the forecast there will be extra costs passed on to the supplier. Such practices will reduce TMS confidence at the supplier level and lead to lower overall SCTMS and reduced collaborative organizational learning and subsequent performance. Astute managers will develop SCTMS systems that provide enough visibility to enable the supplier to be involved with the original forecast and share their expertise and cost data that enable both parties to reach their individual goals.

Another key factor in SCTMS assessment is the current level of technology maturation in the supply chain tools. Enterprise Resource Planning (ERP) is a very mature technology that improves internal TM and subsequently TMS. However, what occurs at the boundaries of the firm with the use of ERP technology will support or deter SCTMS. For example, does the firm's ERP system enable it to seamlessly transfer purchase requirements to suppliers or does this require a suite of e-procurement applications from e-bidding to eperformance? Alternatively, is the data transferred more traditionally by email and fax? This would imply a lower level of maturation and lower SCTMS. While technology is only one part of the collaborative interorganizational learning, its impact is growing and managers must assess their relative sophistication. Leading

ERP firms recognize the need to be more effective at the boundaries. SAP's recent acquisition of Ariba highlights their need to have an improved upstream presence in the supply chain (Jones, S.D, 2012).

If the focal firm and its first tier supplier develop a high level of SCTMS, then over time, this can be logically extended to the supply chain level. Relying on the extensive interdisciplinary literature review in this paper, it is expected that well-developed SCTMS have the potential to not only increase firm level capabilities and performance but also on the broader supply chain level.

In summary, the benefits to managers for the introduction of TMS to SCTMS are twofold. First, it is expected that well developed SCTMS will directly affect the firm's performance through dissemination of expertise among the internal members. Second, additional indirect benefits are expected such as increased collaboration, innovation, enhanced quality and profitability for all members of the supply chain. Perhaps most importantly this SCTMS is not easily duplicated or copied and in line with resource-based theory, can provide a firm with a competitive advantage (Barney & Clark, 2007).

Even though it may seem time consuming to attempt to coordinate individuals within an organization to ensure sufficient levels of their interaction to reach initial levels of transactive memory, it may seem even more time consuming to encourage supply chain members to participate and develop individual memories.

Regardless of these upfront efforts needed, once the capabilities of a SCTMS and its possible long terms effects on organizational performance are realized, the initial commitment associated with coordination should appear minimal in comparison to the magnitude of positive outcomes associated with a well-run TMS.

In order to develop supply chain TMS, managers first need to realize the need for TMS within the supply chain. As previously mentioned, organizations focused on performance, should certainly consider TMS as a highly beneficial organizational knowledge structure. Here, the role of the manager is to make sure that all lines of communication are open and no expertise in withheld. This is mainly because an accurate TMS is unlikely to develop with low levels of communication. Communication and interaction are important because during these processes labeling of information takes place, which allows for specification of the expertise. This is turn is necessary for encoding, that is, making sense of the information, storing and retrieval processes. Managers should encourage intra-organizational members to learn the knowledge network, which means that members should learn 'who knows what'.

Finally, managers should encourage differentiation of knowledge. Frequently, organizations are against specialization of knowledge as managers like to think that anyone within the group should be able to have an even amount of knowledge in each area. This research argues that knowledge differentiation can be more beneficial. This means that managers should encourage diversification of expertise because this ensures that organizational members collectively will have access to a greater pool of knowledge.

Similarly, lines of communication and maximized interaction with supply chain members should be encouraged to ensure that that all active entities within supply chain, have an accurate understanding of which entity is an expert in which area.

1.7. Limitations and Future Research

The first and most natural suggestion for future research is a recommendation to test the proposed model empirically. Prior to that, the conceptual model can also be further expanded. Expansion can also be done on the explication of the processes within a supply chain that lead to the development of SCTMS. Specifically, more focus should be placed on antecedents and dimensions of SCTMS. Moreover, when looking at propositions set forth in this paper, it is important to further examine the effects of communication and interaction among members as it relates to knowledge transfer. Whenever lines of communication are open and access to expertise is free flowing, risk and trust factors should be evaluated. Therefore, the future research should focus on testing the proposed model and its propositions, as well as expanding it by looking at risk and trust factors. This study has its limitations. First, this is a conceptual piece and like every conceptual piece, its significance does not rely on data. Rather, the goal of a conceptual piece is to generate knowledge and become a cornerstone for theory building in a particular area. Considering a rapid decline in the number of published conceptual pieces, yet the substantial number of citations of these pieces, indicates their relative importance to the field of marketing (Yadav, 2010).

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TABLES AND FIGURES

Figure 1-Conceptually Developing the TMS Framework

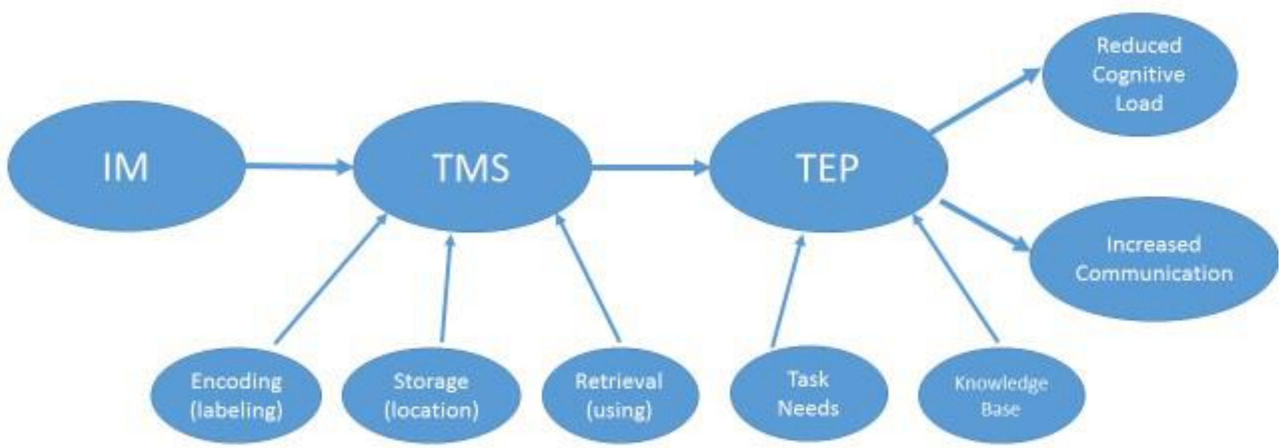

Figure 2: Boundary Spanning TMS in the Supply Chain

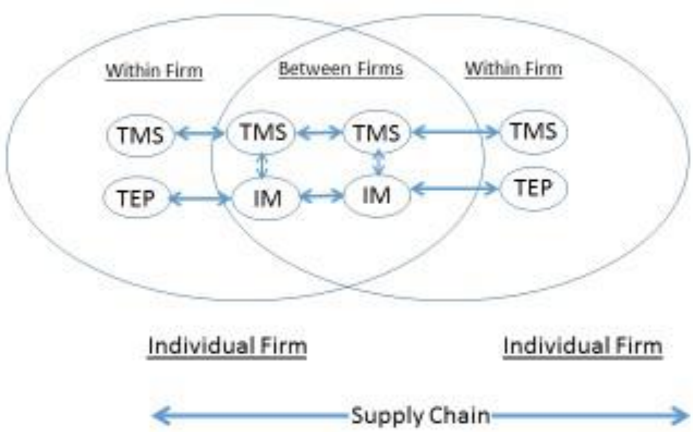

Figure 3 Visualizing SCTMS

$$SCTMS = \sum^{focalfirm} TMS + \sum_{i=1}^{customers} TMS + \sum_{i=1}^{\sup pliers} TMS$$

Note: SCTMS= Sum of TMS of focal firm +
Sum TMS customers + Sum TMS suppliers

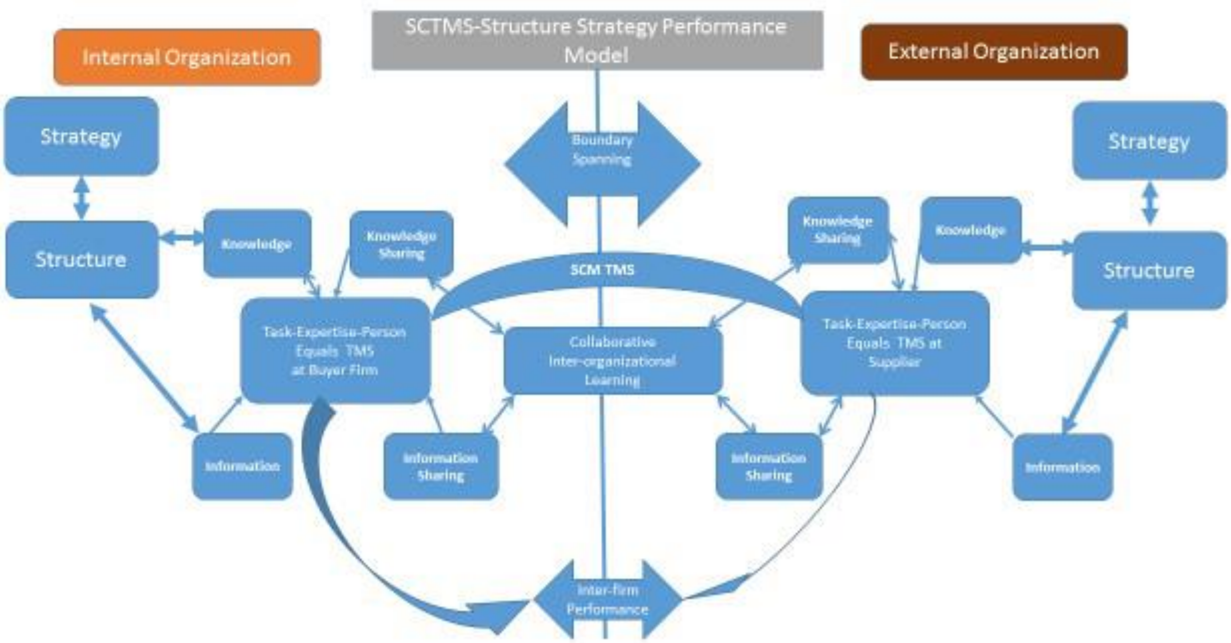

Figure 4 – Strategy Model and SCTMS