Extended Abstract:

Impact of Cloud Computing on Supply Chain Resilience

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Introduction

Today's modern supply chains constitute a global and complex network of enterprises that aim to deliver products in the right quantity, at the right place, and at the right time in an increasingly volatile and unpredictable environment. Persistent instability in global markets exposes supply chains to potential disruptions (Pettit, Fiksel, & Croxton, 2010). Supply chain disruptions can arise from external and internal sources. External supply chain disruption sources include natural disasters (e.g., earthquakes, hurricanes, and tsunamis) or manmade disasters (e.g., accidents, wars, terrorist attacks, strikes, financial crises, and sabotage). Failure to coordinate all operational functions, an occurrence of a fire at a manufacturing plant, or the loss of a critical supplier in a supply chain are all examples of internal supply chain disruptions (Christopher & Peck, 2004; Ponomarov & Holcomb, 2009; Wagner & Neshat, 2010; Soni & Jain, 2011). While a supply chain disruption is the trigger that leads to the occurrence of risk, supply chain vulnerability is the factor that causes loss to supply chains (Wagner & Bode, 2006). Firms can develop effective supply chain risk management strategies to reduce supply chain vulnerability (Manuj & Mentzer, 2008). However, it is difficult to apply these traditional risk management strategies to each link in global supply chains for every possible disruption (Pettit et al., 2010). Therefore, supply chains need a system that identifies, monitors, and reduces supply chain risks; and reacts quickly and cost-effectively to supply chain disruptions (Melnyk, Davis, Spekman, & Sandor, 2010). Ponomarov and Holcomb (2009) call this system as supply chain resilience (SCRES) and define as:

“The adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function.” (P. 131)

One of the three principles of resilience, connectedness, refers to a supply chain partners' level of effective and efficient coordination through an integrated network (Ponomarov & Holcomb, 2009). Connectedness is possible through information sharing (Brandon-Jones, Squire, Autry, & Petersen, 2014).
The sharing of appropriate and timely demand and inventory information among supply chain partners improves supply chain visibility (Brandon-Jones et al., 2014; Christopher & Lee, 2004; Tang, 2006).

Information technology (IT) solutions often provide for more effective supply chain risk management with the ultimate goal of a stockless, risk free supply chain where supply and demand are perfectly balanced (Peck, 2006). However, organizations struggle with the implementation and support cost of IT solutions and the poor quality, visibility, and timeliness of its information (Casey, Jones-Farmer, Yun, & Benjamin, 2012). This is consistent with the World Economic Forum’s (WEF, 2012) supply chain risk survey. According to 64% of the supply chain executives, the second largest area of supply chain vulnerability is the availability of shared information. That implies 64% of major companies don’t have adequate visibility across their supply chain network. In this proposed research, cloud computing, an enabler for collaborative information sharing (Nexus, 2012), is considered to be a cost effective, key technology that improves supply chain capabilities that leads to enhanced SCRES.

Cloud computing in supply chain management is a relatively new concept even as the practical use of cloud computing to support supply chain operations continue to increase. In academic literature, existing studies regarding cloud computing mainly focus on well-known benefits and complications of adopting cloud computing in supply chains (Buyya, Yeo, Venugopal, Broberg, & Brandic, 2009; Casey et al., 2012; Cegielski, Jones-Farmer, Wu, & Hazen, 2012). There is a limited explanation on cloud computing’s impact on supply chains from a theoretical perspective (Wu, Cegielski, Hazen, & Hall, 2013). To address this gap in the literature, we apply relational view (RV) (Dyer & Singh, 1998) and resource-based view (RBV) (Wernerfelt, 1984; Barney, 1991) to develop a conceptual framework and theory driven, testable hypotheses to investigate cloud computing and its impact on supply chain resilience. Therefore, the purpose of the proposed research is to explore the role of cloud computing in influencing SCRES and how SCRES may lead to a sustainable competitive advantage. The proposed research contributes to the literature by developing a theory-driven, conceptual model that explains the relationship between cloud computing and SCRES and other factors influencing this relationship.
Today, CEOs are often unable to economically justify the significant investment required to transition to a cloud based supply chain environment (Sullivan, 2013). The results of this study may help to enhance a CEOs’ understanding on how cloud computing can improve its firm’s competitive position by building resiliency into its supply chains.

**Literature Review and Theory-Driven Hypothesized Relationships**

*RBV and RV*

RBV explains how an organization can achieve a competitive advantage by developing resources and capabilities (Wernerfelt, 1984; Barney, 1991; Barney, Wright, & Ketchen, 2001). In the supply chain resilience literature, there exists studies that utilize RBV perspective to understand the relationships among the resources, supply chain capabilities, and SCRES (Blackhurst, Dunn, & Craighead, 2011; Brandon-Jones et al., 2014). In the present study, we propose cloud computing and information sharing as resources and supply chain agility, flexibility and collaboration as capabilities that may influence SCRES.

RV offers that the competitive advantage of a firm is dependent on the network of relationships (Dyer & Singh, 1998). RV theory emphasizes the relational outcomes such as trust, credibility and effectiveness of the relationship. The trust between the firms improves as they share information (Zacharia, Nix, & Lusch, 2009), and information sharing improves as the level of trust increases (Kwon & Suh, 2004). In this study, we propose trust as a moderator between cloud computing and information sharing.

*Cloud Computing*

From the RBV perspective cloud computing refers to an IT resource that enables information sharing. The cloud computing term is emerged in 2007 (Leukel, Kirn, & Schlegel, 2011). Cloud computing is defined as "a connectivity-facilitated virtualized resource (e.g. software, infrastructure, or platforms) that is dynamically reconfigurable to support various degrees of organizational need, which allows for optimized systems utilization "(Casey et al., 2012).

The fundamental difference between traditional IT systems (e.g., on-premise Enterprise Resource Planning (ERP) systems) and cloud computing offerings is seen in the shift from a push of resources to a
pull of resources. Cloud computing lends itself to on-demand self-service, broad network access, resource pooling, measured service, and reduced total cost of ownership via pay-per-use. The integrity of supply chain visibility is jeopardized when an on premise ERP system’s inventory position is compromised. An example is when the inventory counts at a location do not include the correct in-transit items due to a latency problem. Cloud based supply chain bridges this information gap by providing real-time data on in-transit items and updating it instantly across the supply chain network (Nexus, 2012). Obtaining real-time data and instant updates help supply chain partners to make rapid decisions in response to supply chain disruptions. For instance, a major specialty chemicals player operating in 25 countries used its cloud based supply chain platform to proactively plan for Suez Canal closure due to civil unrests and protests in 2011. Using data from carriers around the world on their cloud based supply chain platform, the company was able to rapidly develop an alternate transport route to for its critical items (Nexus, 2012).

Cloud computing technology executes rapid and accurate statistical demand forecast for all the supply chain partners by reducing the time demand data and resulting forecasts are communicated throughout the supply chain (Schramn et al., 2011). Such processes can lead to a significant decrease of the bullwhip effect, the information distortion among different stages of the supply chain (Lee et al. 1997). For instance, with a traditional on premise ERP system, when a disaster hit, decision makers would have hard time to find data on the status of current inventory, production or availability of alternative transportation modes. Using cloud technology, supply chain partners can see the risks, rapidly develop a plan to mitigate a disruption and as a result, gain competitive advantage.

Lindner et al. (2010) is the first to develop a framework to explain how cloud computing technology applies to supply chains. Lindner et al. (2010) introduces the concept of a “cloud supply chain” and defines a cloud supply chain as “two or more parties linked by the provision of cloud services, related information and funds”. Building on Lindner et al. (2010), Zhou, Zhu, Lin, and Bentley (2012) develop a conceptual model that identifies the benefits and challenges of cloud computing in supply
chains. Later on, Casey et al. (2012) provides and empirically study that analyzes a decision makers' intention to adopt cloud computing technologies in supply chains. To the best of our knowledge, this study is the first to posit an explanatory relationship on how cloud computing impacts SCRES.

**Impact of Cloud Computing on Information Sharing and Moderating Role of Trust**

Gunasekaran and Ngai (2004) suggest that internet-enabled electronic supply chain management systems (eSCMS) provides seamless collaboration among supply chain partners thereby improving the effectiveness and efficiency of a supply chain. Seamless collaboration improves forecasting and planning, which helps to reduce stock levels and stock-outs (Giménez & Lourenço, 2008). However, this is more likely based on the efforts of trust between supply chain partners (Giménez & Lourenço, 2008). In this study, trust is defined as “the belief that the other party will act in the firm’s best interest in circumstances where that other party could take advantage or act opportunistically to gain at the firm’s expense” (Akkermans, Bogerd, & Van Doremalen, 2004). When two organizations have trust, they are more likely to engage in information sharing (Vikram, Prakash, & Amrik, 2012). Building on Akkermans et al. (2004)’s findings, we propose that:

**H1:** Cloud computing has a positive impact on information sharing.

**H1a:** Trust positively moderates the relationship between cloud computing and information sharing: the higher the level of trust, the greater the effects of cloud computing on information sharing.

**Impact of Cloud Computing and Information Sharing on Supply Chain Capabilities**

RBV suggest that when resources are combined, they create capabilities (Barney, 1991). In this study, combination of cloud computing and information sharing resources leads to higher order supply chain capabilities. Supply chain capabilities are defined as the antecedents of supply chain vulnerability that impact both the probability of occurrence and the severity of supply chain disruptions (Sheffi, 2005; Wagner & Bode, 2006). Based on literature, Jüttner and Maklan (2011) synthesize four formative capabilities; visibility, velocity, flexibility and collaboration.

Supply chain visibility refers to clear view of upstream and downstream information such as inventories, demand and supply conditions, and production and purchasing schedules (Christopher &
Peck, 2004). Increasing the visibility of demand information across the supply chain reduces the risks related to information distortion that causes Bullwhip Effect in supply chains (Chopra & Sodhi, 2004).

Supply chain visibility and velocity are the key elements of supply chain agility which implies ability to respond rapidly to unpredictable changes. Velocity refers to the supply chain's reaction time to changes in demand, upwards or downwards (Christopher & Peck, 2004). Reduction in lead-time through improved visibility enhances the velocity (Carvalho, Duarte, & Machado, 2011; Christopher & Peck, 2004). Agility with improved velocity and visibility allows synchronization based on shared information among supply chain partners. Synchronous supply chain requires transparency of demand and inventory information in close to real time. Transparency of demand and inventory information is possible with the availability of the technology and software that enables information sharing (Christopher & Lee, 2004).

Supply chain flexibility refers to the ability to rapidly change processes and facilities to achieve the same goals. Cloud computing enables flexibility by creating a reliable real-time data platform that allows companies to assess inventory in the supply chain and expedite and re-route as necessary.

In the proposed research, supply chain collaboration refers to the tendency of the supply chain partners to align forces in the case of a disturbance event (Carvalho, Duarte, & Machado, 2011). Cloud computing enables high level collaboration through information sharing by reducing inconsistencies and uncertainties in data. Based on the discussion above, we posit that:

H2: Cloud computing has a positive impact on SC capabilities.

H3: Information sharing has a positive impact on SC capabilities.

Impact of Supply Chain Capabilities on SCRES

According to Haimes (2006), the goal of the SCRES is: 1) to recover to the desired state of the system within an acceptable time and cost, and 2) to reduce the impact of a disturbance by changing the effectiveness level of a potential threat (Carvalho, Barroso, Machado, Azevedo, & Cruz-Machado, 2012b). The goal of SCRES can be achieved by enabling the shift towards desirable states in which failure modes would not occur (Carvalho, Azevedo, & Cruz-Machado, 2012a). For instance, when faced with a disruption, a resilient supply chain would shift flow to other customers and markets so that its
supply source continues at full operating rates (Bradley, 2005). However, “resilience depends on choices made before the disruption than the actions taken on the midst of the disruption” (Sheffi, 2005). Therefore, to enable such a shift towards to desirable state, resilience needs to be designed into supply chain (Christopher & Peck, 2004). Resilience can be designed into supply chain by developing various capabilities. Resilience capabilities reduce the vulnerabilities by detecting, preventing or reducing the occurrences of supply chain disruptions. The formative capabilities of SCRES (agility (visibility & velocity), flexibility, collaboration) are based on integrating and coordinating resources that enhance the SCRES (Jüttner & Maklan, 2011). The degree of these capabilities influences the quick response to changes in demand and recovery after a disturbance (Carvalho et al., 2012a). In the proposed study, cloud computing is utilized as an enabler of four formative capabilities of supply chain resilience through information sharing. Based on the discussion about capabilities, we propose that:

**H4:** SC capabilities have a positive impact on SCRES.

**Impact of SCRES on Sustainable Competitive Advantage**

From the RBV perspective, capabilities that are obtained from integrating resources create core competencies which lead to sustainable competitive advantage (Prahalad & Hamel, 1990). In today’s global business environment, being resilient to cope with disruptions is not enough. It is important to turn the resiliency’s positive impact on a firm’s performance into a competitive advantage (Carvalho et al., 2012a; Sheffi, 2005). Under uncertain conditions, supply chain resilience plays a key role in sustaining capabilities and creating competitive advantage (Ponomarov & Holcomb, 2009). Therefore, we posit that:

**H5:** SCRES has a positive impact on sustainable competitive advantage.

Building on Brandon-Jones et al. (2014)'s model, we develop the following conceptual model as illustrated in Figure 1.
Figure 1. The conceptual model

Proposed Methodology

Since this study is exploratory in nature, in the future we will conduct surveys to test the proposed conceptual model. The survey questionnaire will be based on existing scales. Variables will be measured using established scales in the literature. Instead of focusing on a single industry, this research will be focused on developing a broad understanding of cloud computing’s impact on SCRES. Therefore, multiple industries will be included in the sampling frame. Potential respondents for the survey will be the organizations that use cloud computing to manage their supply chain operations. A questionnaire will be sent to cloud service providers for supply chains such as One Network and GTNexus.

Conclusions and Future Research

We propose a theory-based, conceptual model based on RBV and RV and a review of supply chain, supply chain resiliency, and cloud based technology literature. Future research will empirically test the proposed conceptual model to examine the impact cloud computing has on SCRES. We hope that the results of this study would help supply chain managers and executives to better understand cloud
computing's impact on SCRES when making strategic decisions to improve a firm’s competitive advantage.

In the literature, the concept of cloud based supply chain management is still new and theoretical frameworks are still in its infancy (Casey et al., 2012). Therefore, an additional understanding of the phenomenon of interest could be gained by using a qualitative approach, such as grounded theory. Further conceptualization using additional constructs would be highly recommended. In addition, future research can incorporate behavioral aspects of the SCRES.
REFERENCES


