

SUPPLY CHAIN SENSING CAPABILITY IN AUSTRALIAN MANUFACTURING ORGANIZATIONS AND DYNAMIC CAPABILITES

Oluseye Odukoya & Richard Oloruntoba

Newcastle Business School

The University of Newcastle

409 Hunter Street, Newcastle, Australia

Corresponding author: Richard.Oloruntoba@newcastle.edu.au

1. Introduction

Volatility, uncertainty, complexity and ambiguity (VUCA) of the business environment is intensifying. This is characterized by increasing competition, changing market and customer demands, advancing technology, and explosion of data (Teece 2019). As a result, many firms are struggling due to their inability to address the increasing uncertainty and complexity in the business environment. (Vergne & Depeyre, 2016; Teece, 2019).

Addressing VUCA in the business environment requires firms to rapidly reconfigure their capabilities but this takes time to do. Thus, firms need some form of radar to identify, evaluate, interpret and act on leading indicators of change. This radar is often referred to as 'organizational sensing'; a crucial activity for organizational survival in today's business environment (Teece 2007; Teece 2014a). The challenge is how firms can be quickly alerted to changes in the business environment, seize the opportunities presented and reconfigure their capabilities in order to adapt and sustain competitive advantage overtime in rapidly changing business environment (Winter, 2018).

Early scholars on competitive strategy research relied on several theoretical perspectives to explain heterogeneity in competitiveness across firms. These theoretical perspectives were based on for instance, organizational economics (e.g., Jensen & Meckling, 1976; Nelson & Winter, 1982; Williamson, 1975), organizational theory (e.g., Weber, 1947; Katz, & Kahn, 1966), and organizational behaviour (e.g., March & Simon, 1958; Simon, 1955). Examples of these include the transaction cost economics (Williamson, 1975, 1985), evolutionary view of the firm (Nelson & Winter, 1982), agency theory (Ross, 1973), and decision-making theories (Cyert & March, 1963; March & Simon, 1958; Simon, 1955). These theoretical perspectives rely on the assumption that the firm is independent of the market and the competitive context within which it operates.

However, such assumptions were deemed insufficient in explaining firm competitiveness, performance, and survival by advocates of the resource-based view (RBV) of the firm (e.g. Barney, 1986, 1991; Collis, 1994; Penrose, 1959; Rumelt, 1984; Warnerfelt, 1984). Advocates of the RBV argue that the content of a firm's strategy and its broader competitive context and environments are important conditions in understanding firm competitiveness (Barney & Zajac, 1994). The RBV of the firm asserts that the firm is a collection of resources and capabilities which serves as the source of competitive advantage for the firm as long as the resources and capabilities are found to be valuable, rare, inimitable and non-substitutable (Barney, 1991). However, in the light of recent hyper-volatile environments characterized by VUCA, existing capabilities have been shown to very quickly become obsolete. Thus, the RBV is insufficient in explaining firm competitiveness and performance (Teece, Peteraf, & Leih, 2016).

The dynamic capabilities (DC) perspective was thus formulated to address the shortcomings of the RBV by introducing a dynamic element to it (Teece & Pisano, 1994). The DC perspective attempts to explain "the sources of enterprise-level competitive advantage over time" (Teece 2007, p. 1320). DC was originally defined as 'the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments' (Teece, Pisano, & Sheun, 1997, p.516). They assert that these dynamic capabilities are developed from the firm's asset positions and evolutionary paths (Teece et al., 1997).

Research on DC have since progressed and highlighted the importance of organizational culture, managerial capabilities and organizational capabilities in determining the sources of competitive advantage (Helfat & Martin, 2015; Teece 2007, 2014a, 2014b, 2016, 2018). Recent developments in the DC view reaffirms the importance of supply chain-like integration of internal and external partners' capabilities into the development of unique processes, business models, resources and strategy

required to achieve high-performance sensing, seizing and reconfiguring capabilities (Teece, 2014b, 2018). Accordingly, the DC view has been increasingly acknowledged by researchers in the SCM, business and management field, and the view has become influential in recent times (Mikalef & Pateli, 2017; Pisano, 2017; Salvato & Vassolo, 2018; Schilke, Hu, & Helfat, 2018; Wilden, Devinney, & Dowling, 2016).

This paper advocates for a supply chain and supply chain management role in the further development of the dynamic capabilities of firms, and in the theoretical development of the dynamic capabilities view. This position is premised on the firm supply chain acting as a sensing mechanism for identifying strategic threats and opportunities in the firm environment.

This paper advocates for more managerial, researcher and theoretical attention to be paid to three important strategic processes and activities: (1) identifying and assessing opportunities and threats in the environment (sensing) (Teece, 2007), (2) addressing opportunities and threats through implementing business processes to capture value (seizing) (Teece, 2007), and (3) continuous renewal of the firm's resources and capabilities (reconfiguring) (Teece, 2007). The adopted DC perspective in this paper argues that in times of rapid change, the capability to (a) sense and shape opportunities and threats, and (b) reconfigure the firm's assets and resources in a quick and proficient manner to seize those opportunities is necessary to achieve, maintain and improve competitiveness (Teece, 2007).

The rest of the paper is structured as follows: Section 2 introduces the research problem. Section 3 introduces the literature review, research gaps and research aims. Section 4 presents the research method adopted for the research including sampling and data collection and analysis, Section 5 presents the results, while section 6 presents the preliminary theoretical model to be tested in the case studies down the line.

2. Research problem

A fundamental reason for business failure is the inability to effectively generate, process, and evaluate data about current and future changes in market trends, and turn them into valuable insights (Satell, 2018). The traditional focus of DC has been internal within the single focal firm with the sensing, seizing and reconfiguring triad of DC viewed as processes occurring solely within the firm (Baretto, 2010). However, recent research indicates that cross-organizational capabilities that cut across multiple firms such as the supply chain are essential to create and maintain competitiveness (Craighead, Hult, & Ketchen Jr. 2009; Defee & Fugate, 2010; Ketchen Jr & Hult, 2007). Thus, the need for greater research attention in understanding DC beyond firm boundaries, and to capture the role of the supply chain and supply chain network (Eckstein et al., 2015; Dubey et al., 2018). Hence, this paper's attempt to advocate for, and understand how the supply chain may be used to generate business insights for competitive strategy.

3. Literature review, research gaps and research aims

Firms focus on core competencies, skills and capabilities while relying on an external network of partners, suppliers, customers and other firms for other resources and capabilities that serve as sources of competitive advantage for the firm (Li, Ragu-Nathan, Ragu-Nathan, & Rao, 2006; Vanpoucke, Vereecke, & Wetzels, 2014). These often cut across inter-organizational routines, networks and processes (Dyer & Singh, 1998). Furthermore, supply chain partners operate in different environments and with different partners (Mentzer et al., 2001). As a result, they are exposed to potential opportunities and threats that may not be captured by the experiences of a single firm. Consequently, the supply chain partners provide insights into such opportunities and threats that the single firm may be unaware of (Hult et al., 2007; Vanpoucke et al., 2014).

3.1 Competitive advantage, organizational routines and organizational capabilities

Competitive advantage has been referred to as superior performance, supranormal returns, pure profit, profits in excess of opportunity costs (Arend, 2015). Competitive advantage is the degree to which an organization is able to differentiate and maintain a defensible position over its competitors (Li et al., 2006). Theories of competitive advantage include perspectives that seek to explain heterogeneity in firm competitive strategies and performance differences (Powell, 2001).

Organizational routines are important aspects of organizations as they are regarded as the means through which organizations function (Feldman & Pentland, 2003). Underlying organizational

capabilities are organizational routines (Eggers & Kaplan, 2013). Organizational capabilities, whether dynamic capabilities or operational capabilities draw on organizational routine elements (Feldman, 2000). Feldman & Pentland (2003, p. 95) define organizational routines as “repetitive, recognizable patterns of interdependent actions, carried out by multiple actors”. However, they are not necessarily static (Feldman & Pentland, 2003). Organizational routines do not constitute just habit and inertia (Gavetti, Greve, Levinthal, & Ocasio, 2012). They are also sources of organizational knowledge that facilitates learning and change (Feldman, 2000; Feldman & Pentland, 2003; Pentland, 2003). Pentland, Hærem, & Hillison (2011) elaborated on this perspective by providing empirical support for the duality of organizational routines as sources of stability, as well as agents of change in organizations.

Accordingly, Eggers & Kaplan (2013) define routines as “patterns of actions that constitute organizational skills” (p.302), and as such can foster stability and create a basis for evolutionary change of the firm (Parmigiani & Howard-Grenville, 2011). Knott (2001) also argued that in business reconfiguration, routines perform a dual role of creating change, and retaining operational routines. Organizational routines are built from a collective process that develops beliefs about peoples’ interests and what activities should be carried out; enabling the firm to engage in processes of sensing, seizing and reconfiguring (Eggers & Kaplan, 2013).

Experience forms the basis of organizational routines through behavioural mechanisms such as the degree of success, familiarity, and regularity of experiences. However, the conversion of experiences to routine depend largely on cognitive frames that determines the interpretations of the value and usefulness of such experiences (Gavetti et al., 2012). Parmigiani & Howard-Grenville (2011) identified two views of routines: the capabilities perspective which focuses on how routines affect firm performance, and the practice perspective which is interested how routines are utilized by individuals and their internal dynamics. This paper draws on the capabilities perspective as the concern is on how routines constitute underlying elements of organizational capabilities.

Organizational capabilities have been referred to with terms such as ‘organizational competencies’, ‘organizational resources’, ‘resource base’, thus creating contradictions when not properly clarified (Wu, Melnyk, & Flynn, 2010). This paper adopts the term ‘organizational capabilities’. Collis (1994) defines organizational capabilities as “socially complex routines that determine the efficiency with which firms physically transform inputs into outputs” (p.143). Organizational capabilities are concerned with the deployment, allocation and coordination of organizational resources, the functions of organizational routines and how they create value for the firm (Parmigiani & Howard-Grenville, 2011; Wu et al., 2010).

The development of organizational capabilities is driven by internal and external organizational processes of coordination, learning and transformation, and occurs gradually over time (Wu et al., 2010). Elevation of routines and resources to capabilities depends on the level of organizational learning that the organization engages in, and the decisions managers take overtime (Eggers & Kaplan, 2013). Hence, Eggers & Kaplan (2013) assert that the assembly of capabilities from the building blocks of routines is influenced by the cognition of managers and that, thus, organizational capabilities are firm specific, time dependent, tacit, and path dependent ingredients for organizational success (Wu et al., 2010).

Organizational capabilities exist at different levels of the firm and can be classified as: operational capabilities – concerned with regular operations; or dynamic capabilities – involving modification and change with time (Winter, 2003). Examples of operational capabilities include human resource management capabilities, manufacturing capabilities, supply chain capabilities, etc. that enable firms to function and perform their daily tasks (Winter, 2003). The key distinction between operational capabilities and dynamic capabilities is one of regular repetitive operations versus those of modification, change, evolution and dynamism (Helfat et al., 2007; Winter 2003).

3.2 Dynamic capabilities, sensing, seizing and reconfiguring

Teece et al. (1997, p.516) define DC as “the firm’s ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environment”. Winter (2003, p. 991) define DC as “those (capabilities) that operate to extend, modify, or create ordinary capabilities” in changing environments. Operational capabilities are the routines that enable the firm to perform its daily tasks effectively and efficiently in a repeated and reliable manner (Helfat & Winter, 2011). Whereas DC

involves a process comprised of routines and practices through which operational capabilities are changed, modified, renewed or created (Helfat & Peteraf, 2003). By layering DC on operational capabilities, firms can maintain and extend competitive advantage through driving systematic changes in existing operating routines for the generation of future profits in response to, and in adapting to changes in the environment (Teece, 2010; Zollo & Winter, 2002).

In order to modify existing operational capabilities, firms engage in three processes of (1) sensing opportunities/threats (Teece, 2007), (2) seizing opportunities (Teece, 2007), and (3) reconfiguring the resource base (Teece, 2007). Sensing involves identifying and assessing opportunities and threats as they pertain to the proficiency of operational capabilities. Seizing refers to a process through which operational capabilities and related resources are mobilized to address identified opportunities and threats, and also to generate value from the use of those resources, while reconfiguring is the renewal of the firm's operational capabilities and resource base (Teece, 2007, 2010). In times of rapid change, the capability to sense and shape opportunities and threats, and reconfigure the firm's assets and resources in a quick and proficient manner in order to seize those opportunities is necessary to achieve, maintain and improve competitiveness (Teece, 2007).

While operational capabilities can be a source of competitive advantage at a given point in time, DC secure the sustainability of firm-level competitive advantage for the long term (Teece 2007, Pitelis & Teece, 2009; Protogerou et al., 2011). DC do not automatically emerge, DC requires the deliberate effort on the part of organizational managers and leaders in recognizing key developments in the business environment, delineating responses, and orchestrating clusters of skills and capabilities that enables the organization to respond, gain and maintain competitive advantage (Adner & Helfat, 2003). Other organizational factors such as the organization's values, culture, and structure may contribute to the strength or weakness of a firm's DC (Shuen, Feiler, & Teece, 2014). Firms must therefore be able to establish the ability to discern when to exploit or explore in order to avoid failures resulting from overreliance on past (successful) experiences and activities on one hand, and pursuing bad ideas on the other hand (O'Reilly & Tushman, 2008).

The sensing process is a key component of DC that provides the fundamental basis for firms to seize opportunities, reconfigure operational capabilities (Eisenhardt & Martin, 2000), and undertake organizational adaptation (Hambrick, 1981). Aslam, Blome, Roscoe, & Azhar (2018) reaffirmed the position that the capability to sense opportunities is a necessary condition for effective seizing and reconfiguring. Sensing involves the continuous generation of data about the business environment in order to identify opportunities and anticipate potential threats (Heusinkveld, Benders, & van den Berg, 2009; Winter 2018). However, it is not enough to simply generate data from the environment. The sensing process requires evaluating and translating data generated into valuable insights by continuously engaging in information processing activities, supported by internal organizational capabilities (Galbraith, 1973).

Sensing extends beyond the boundaries of the firm (Teece, 2007). Sensing involves gaining insights about the internal and external environments of the organization, and making strategic decisions based on an evaluation of the insights (Teece, 2007). Sensing encompasses gaining insights about competitors, customers, suppliers and other elements of the business ecosystem. Sensing capability is the capacity of the firm to capture opportunities and threats in the environment through scanning, search and exploration activities across technologies and markets by harnessing the capabilities of customers, suppliers and R&D partners (Teece, 2007). Such opportunities have to be sensed before it becomes apparent to competitors (Teece, Peteraf & Leih, 2016). Sensing has been studied from different perspectives, majorly in the marketing and strategy literature and akin to scanning (Danneels, 2008; Zhou & Li, 2012), environmental scanning (Garg, Walters, & Priem, 2003), integration sensing (Vanpoucke et al., 2014), market sensing (Aslam et al., 2018; Day 1994; Heusinkveld et al., 2009; Murray et al., 2016; Slater & Narver 2000), systematic sensing and scanning (Day, 2011), strategic sense-making (Pandza & Thorpe, 2009), opportunity-recognizing integrative capabilities (Liao, Kickul, & Ma, 2009) and market-sensing capability (Bharadwaj & Dong, 2014; Fang, Chang, Ou, & Chou, 2014).

There is consensus that sensing nurtures and sustain DC (Aslam et al., 2018; Dannels, 2008; Teece, 2007; Wilden & Gudergan, 2015). Sensing involves paying attention to both the firm's internal and external environment (Garg et al., 2003). However, sensing as a component of DC is more external oriented focusing on detecting, identifying, filtering and calibrating market opportunities, while seizing

and reconfiguring are internal-oriented focusing on exploiting opportunities through structures, procedures and processes within the firm (Liao et al., 2009; Wu, Chen, & Jiao, 2016).

As such, in turbulent environments, firms tend to rely on external knowledge for sensing; through relationships with customers, suppliers, educational institutions and professional bodies (Wilden & Gudergan, 2015), thus leveraging opportunities within those domains (Danneels, 2008). In addition, exploratory activities that extend beyond the boundaries of the firm have been argued to generate stronger impacts (Rosenkopf & Nerkar, 2001).

Seizing is when opportunities and threats have been sensed and firms need to seize these identified opportunities, and respond to emanating threats by evaluating investment options, engaging in strategic investment to develop new capabilities, and designing new business models, which may have long-term effects on firm performance (Helfat & Peteraf, 2015; Teece, 2007). Seizing processes involve the generation of alternative solutions to problems identified, and addressing opportunities sensed through creative activity with the aim of generating new processes to address such opportunities (Teece, 2007). Generation of alternatives and options may involve searching within the organization for solutions, or developing new solutions (Teece, 2007). Due to time pressures, routines, guidelines, operating procedures, and policies, generated alternatives are often limited (Miller & Lin, 2015). Of importance to the seizing process is effective decision making that captures opportunities while mitigating potential risks (Feiler & Teece, 2014; Hodgkinson & Healey, 2011). Effective seizing of opportunities requires the ability to overcome reliance on existing successful organizational strategies in order to minimize decisional bias, inertia and persistence which can lead to undervaluing new opportunities and innovative investments (Hodgkinson & Healey, 2011).

Reconfiguring ensures the sustenance of growth and profitability in dynamic markets and it involves aligning, re-aligning, combining, and enhancing the firm's organizational resources and capabilities (Helfat et al., 2007). In fast-moving markets such as in technology, firms need to engage in continuous renewal in order to create a fit with the opportunities they plan to address (Teece, 2016). Reconfiguring may involve recombining existing resources or acquiring entirely new resources, depending on the intensity of change confronting the organization (O'Reilly & Tushman, 2008). An incremental change may involve gradual transformation of the firm's resources, while rapid changes will likely require rapid realignment of the firm's resources (O'Reilly & Tushman, 2008). The reconfiguring element of DC is sometimes referred to in the literature as 'transforming' (e.g. Feiler & Teece, 2014), or 'shifting' (e.g. Teece et al., 2016).

On the other hand, commitment to existing procedures, routines and assets makes it difficult for firms to flexibly and responsively engage in sustained and continuous reconfiguring, especially if the firm is currently performing well (Teece, 2010; Teece et al., 2016). Associated costs and risks involved in the transformation process may also serve as barriers to firms seeking to reconfigure (Feiler & Teece, 2014). Consequently, effective reconfiguring requires the ability of organizational leaders to be change-oriented, willing to commit resources, and capable of motivating and inspiring organizational members on the need for change even when the need is not immediately obvious (Feiler & Teece, 2014).

Leveraging the supply chain for sensing can enrich the firms' market knowledge and better understanding of unexplored market segments, triggering engagement in reconfiguring processes thereby improving their existing operational capabilities such as their marketing and technological capabilities through reconfiguring their resources, capabilities, structures and processes; and ultimately improve firm performance (Vanpoucke et al., 2014; Wilden & Gudergan, 2015). As Teece (2007, p.1322) notes, sensing does "not only involve investment in research activity, it also involves understanding latent demand, the structural evolution of industries and markets, and likely supplier and competitor responses".

Research on the underpinning mechanisms and activities through which DC, DC elements of sensing, seizing and reconfiguring are actually identified and developed remain underexplored and thus limits understanding in DC related strategic supply chain management research (Pisano, 2017; Schilke et al., 2018). To improve the understanding of how DC may facilitate sustainable competitive advantage, it is important to understand the underlying processes involved in the deployment of DC and how they can be improved.

Thus, this paper explores the role of the supply chain (upstream and downstream) as regards DC and sensing. The upstream supply chain refers to the firm’s supplier while the downstream supplier chain refers to the firm’s customers (Mentzer et al., 2001). This paper makes important theoretical contributions to research on strategic supply chain management research, dynamic capabilities, and information processing. It advocates the importance of sensing, seizing and reconfiguring as important elements on which DC are developed. The paper demonstrates that the supply chain plays an important role in the sensing, seizing and reconfiguring process. By harnessing information provided by supplier and customers, through the key dimensions of supply chain sensing capability (SCSC) (data generation, data vetting, data assessment and data evaluation), firms can improve the development and deployment of DC through enhanced sensing. Thus, the paper investigates the activities and mechanisms through which firms develop their sensing capabilities and improve their sensing performance in order to boost their performance through onward seizing and reconfiguring.

3.3 Research aims

The research aims to: (1) better understand what sensing is through a review of the relevant literature; (2) explore the extent to which sensing is important to the development of DC through literature reviews, case studies and interviews with managers in the New South Wales manufacturing sector; and (3) develop, refine and validate a preliminary theoretical model of sensing, seizing, and reconfiguring to be tested in future research.

3.4. Development of a preliminary theoretical model

We first completed theory building activities involving a review, synthesis, and summarisation of extant literature on strategic supply chain, dynamic capabilities and information processing above from which we developed a preliminary theoretical model of how firms use information provided by their upstream supply chain (suppliers) and downstream supply chain (customers) in sensing, seizing, and reconfiguring activities (Fig 1).

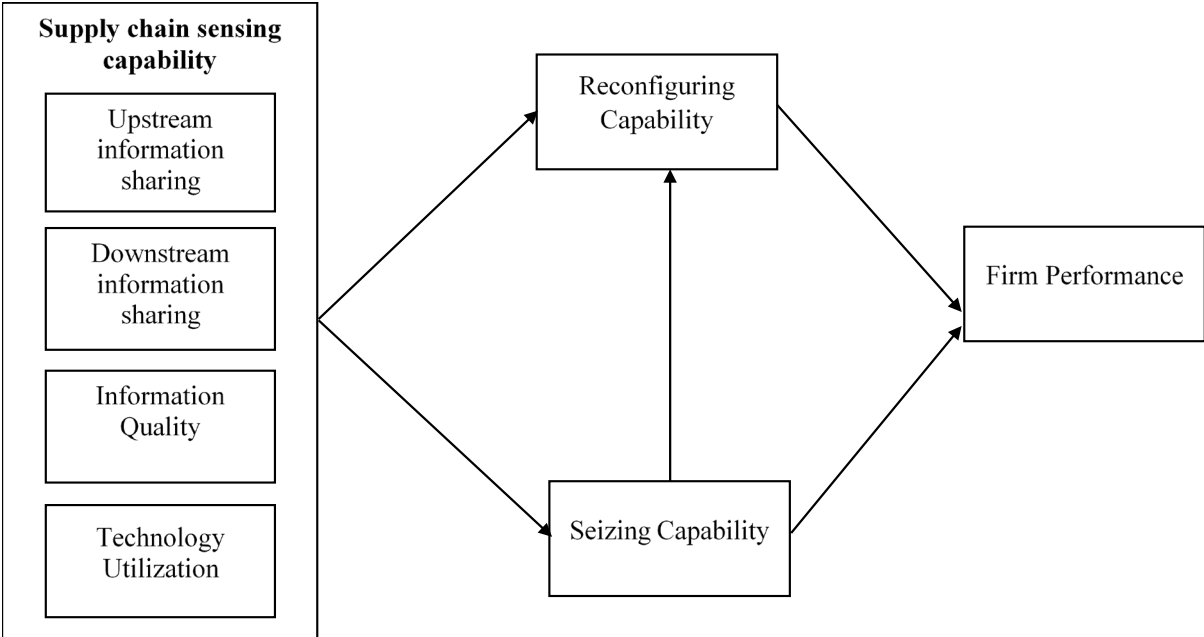


Figure 1 Preliminary theoretical model

The developed preliminary theoretical model in Figure 1 was built on the theoretical concepts of upstream information sharing, downstream information sharing, information quality, technology utilization, and the three DC elements of sensing, seizing, and reconfiguring. Extant literature provides a large number of activities involved in sensing and will be difficult and impractical to address all exhaustively (e.g. Danneels, 2008, Jantunen, 2005; Wilden et al., 2013). Thus, supply chain sensing capability (SCSC) (Fig 1) is conceptualized as consisting of four key components: upstream information

sharing e.g. with the supplier base, downstream information sharing e.g. with the distribution and marketing channels and customers, information quality, and technology utilization. The choice of SCSC components is driven by the focus on the key supplier focal firm relationship and the key customer focal firm relationship. The developed preliminary theoretical model represents the interrelatedness between the firm's SCSC; the sensing, seizing, and reconfiguring dimensions of DC; and firm performance. The model argues that the SCSC impacts firm performance through the mediating roles of the seizing capability and reconfiguring capability. The developed preliminary theoretical model importantly, also includes the quality, relevance and timeliness of information being shared in the supply chain, and lastly, whether appropriate information and communication technology (ICT) that efficiently and seamlessly links the relevant upstream information sharing partners and downstream information sharing partners has been deployed (e.g. electronic point of sales systems). The preliminary theoretical model (Fig 1) was then presented to managers for their evaluation as discussed below in section 4 (methods).

4. Method, sampling and data collection and analysis

We presented the preliminary theoretical model (Fig 1) to eight Australian manufacturing firms in the Hunter region of NSW to evaluate, refine and validate through a qualitative multiple case study approach consisting of face-to-face interviews. Consequently, as a result and as an output of this evaluation, refining, and validating process with managers, we present a (new) refined and validated theoretical model (Fig 2) based on the emerging themes from the case studies and practical inputs from the manufacturing managers. The case studies involved face-to-face interviews of executives of eight Australian manufacturing firms in the Hunter Valley region of New South Wales, Australia. The eight Australian manufacturing companies were recruited through *Hunternet*, a professional association of manufacturers in the Hunter Valley region of New South Wales, Australia (www.hunternet.com.au). Data collected from the case studies were analysed using through thematic analysis, with the aid of NVivo 12 (www.qsrinternational.com). This approach is consistent with the appropriateness of qualitative case-study approach in exploratory research (Yin, 2003). Data collected from the multiple case study was analysed using NVivo12, a Computer Assisted Qualitative Data Analysis Software (CAQDAS) produced by QSR international (www.qsrinternational.com). The research design and research instruments (interview guide) adopted was approved by the University of Newcastle Human Research Ethics Committee in accordance with the requirements of the *National Statement on Ethical Conduct in Research Involving Humans*. Accordingly, the research was conducted in strict compliance to the approved protocol on issues relating to consent, privacy and confidentiality of respondents and participants. The research was granted ethics approval number: H-2017-0427. All these documents are available on request due to word length constraints.

5. Results: Refined and validated model of supply chain sensing capability

Following in-depth analysis and comparing across the case firms, this section presents a refined and validated theoretical model grounded in the empirical evidence provided by the eight cases and informed by the DC theory and information processing perspectives. The refined model explains how the supply chain can improve the sensing element of the DC theory and in turn improve firm performance (see Fig 2 for the refined validated theoretical model).

This study began with the fundamental assumption that firms can sense opportunities in the environment better and quicker by leveraging their supply chain; particularly their suppliers and customers through downstream information sharing, upstream information sharing, information quality, and technology utilization. The preliminary model provided directions for the case study. The preliminary model shows four underlying elements of SCSC as initially presumed (Fig 1).

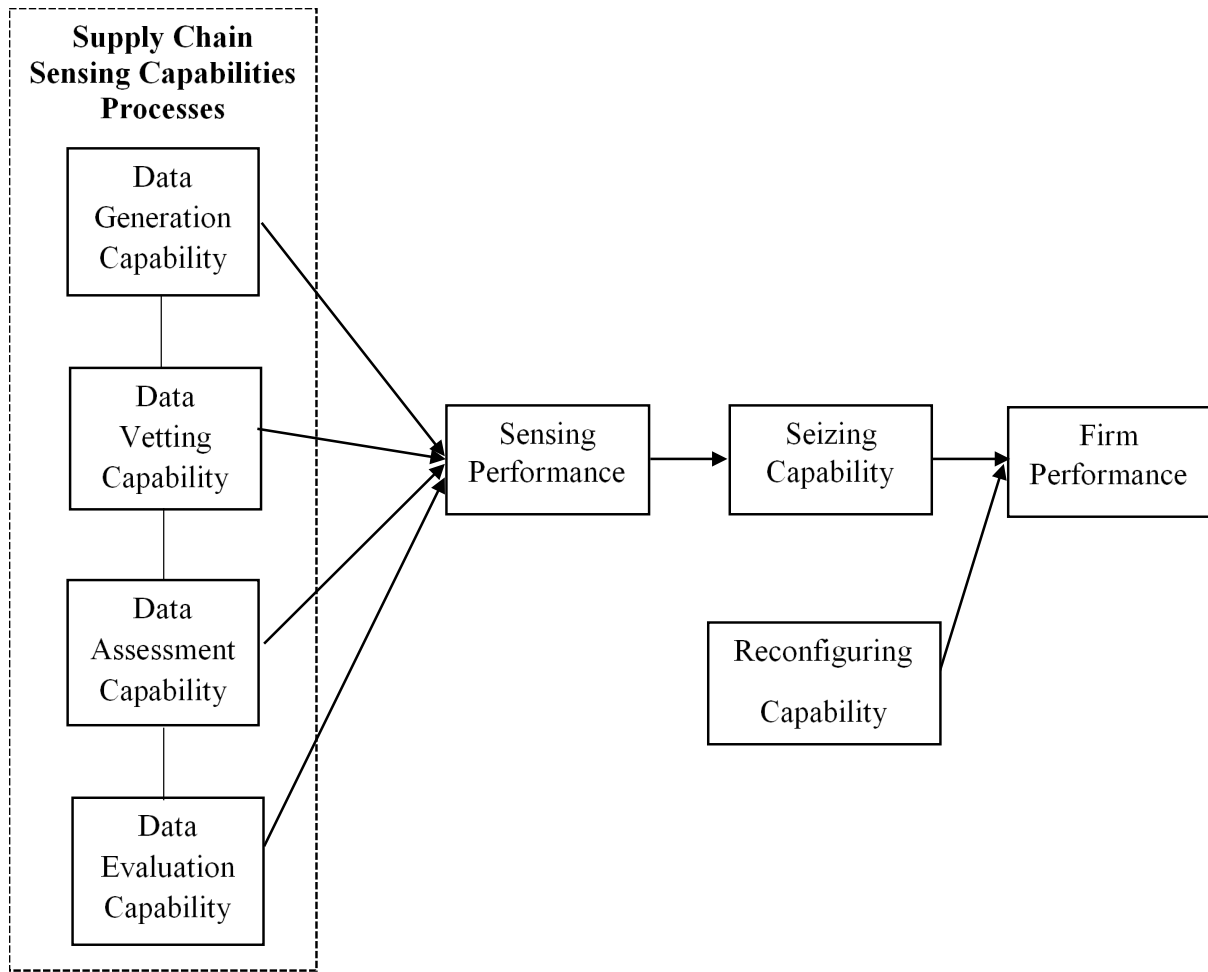


Figure 2. Refined and validated model

Findings from the case study indicate that there is a role for the supply chain in building DC. It shows that suppliers and customers can serve as sources of sensing mechanisms for the identification of opportunities and threats in the business environment. This is driven through supply chain sensing-supplier information sharing and customer information sharing. This notion is consistent with Teece's (2007, p. 1323) argument that opportunity creation and discovery requires access to information- not just through investment in research activity, but also by understanding customer, competitor and supplier responses. Information sharing is thus important to sensing capability. However, what is generated from the supply chain is actually data that is unstructured, voluminous and complex, and not information (nowadays, called big data). The concepts of data and information has been used interchangeably (Drucker, 1988). However, this study relies on the notion that a clear distinction exists between the two concepts. Data consists of characters, which may include word, text, and numbers in raw form and without specific contexts. On the other hand, information refers to data, which have been processed, organized, structured and presented in specific contexts to make them meaningful (Drucker, 1988). Thus, the challenge for firms is how to separate the hidden essential data from the non-essential data while minimizing time to insight in order to achieve clarity.

In order to address the challenge, this refined and validated model helps to understand how firms manage the flow and processing of data through the lens of the information processing perspectives (Galbraith 1973). The information processing perspective postulates that information-processing mechanisms should be aligned with information processing capabilities in order to create an appropriate fit between an organization's ability to handle information and the required information.

In applying elements of the information processing perspective and drawing from the findings from the case study and DC literature, this study proposes the validated model shown in Figure 2. The study proposes SCSC as a higher-order, hierarchical model manifested in four first-order constructs:

(1) Data generation capability (2) Data vetting capability (3) Data assessment capability, and (4) Data evaluation capability. The study argues that data generation capability, data vetting capability, data assessment capability and data evaluation capability have significant impacts on sensing performance; which in turn influences firm performance either directly or indirectly through the mediating role of the seizing capability and reconfiguring capability.

5.1 Data generation capability, data vetting capability, data assessment capability and data evaluation capability

Today's supply chain is characterized by massive flows of data, thus transforming the design and management of supply chains (Hazen, Boone, Ezell, & Jones-Farmer, 2014). *Data generation capability* refers to the ability of organizations to gather data from their upstream and downstream supply chain. This involves data on business processes, technological innovations, changing needs and events, and opportunities and threats in the business environment. Data generation capability is supported by tools and technologies such as electronic point of sale scanners. Web transaction and ecommerce data is also important (Davenport, Harris, De Long, & Jacobson, 2001). The use of radio frequency identification (RFID) has resulted in generation of large amounts of data throughout the supply chain, and from sources such as ERP systems, customer demand patterns, global positioning systems (GPS), mobile devices, audio-visual sensors, and others (Govindan, Cheng, Mishra, & Shukla, 2018).

Data vetting capability refers to the ability of the organization to apply techniques aimed at sifting or filtering data generated from their upstream and downstream supply chain. In today's business environment, most organizations in the supply chain have access to large volumes of data from multiple sources (Hazen, et al., 2014). The challenge is on how to filter this data in record time in order to generate usable and valuable knowledge (Watts, Shankaranarayana, & Even, 2009). The paper finds that firms adopt four mechanisms in filtering data gathered from their upstream and downstream supply chain: (1) trust (2) nature of supply chain relationship (3) duration of supply chain relationship, and (4) regulatory compliance. This is in line with the assertion that the relevance and believability dimensions of data quality are difficult to evaluate objectively (Watts et al., 2009).

According to the case analysis, data generated from close trusted suppliers and customers are usually treated as more important and more credible compared to data generated from suppliers and customers who are not trusted by the firms. Data received from suppliers and customers that engage in collaborative relationships with the firms are usually treated as more important and more credible compared to data generated from suppliers and customers involved in transactional relationships with the firms. Data generated from long term suppliers and customers are treated as more important and more credible compared to data generated from new suppliers or customers who only share short-term relationships with the firms. In addition, firms tend to treat data generated from suppliers and customers that are known to comply with industry regulations and standards as more important, and more credible than data generated from suppliers and customers that do not conform to regulations and standards. The ability to transform data to useful information is made possible by the internal organizational capabilities that the firm possesses. These capabilities are required to understand, process, analyse the data, and use the information generated (Heusinkveld et al., 2009).

Data assessment capability refers to the ability of firms to evaluate the data generated from upstream and downstream supply chain through the use of information technology capabilities. It includes the hardware and software involved in data gathering, data filtration, data extractions, and data analysis (Davenport et al., 2001). Such capabilities may involve direct computer-to-computer links with supply chain partners and inter-organizational coordination using electronic links. The implementation of appropriate information and communication technology (ICT) and advanced information systems, and having the required skill sets and experience required to evaluate supply chain data enables efficient transactions and data processing techniques, and most importantly makes actionable information available to managers (Watts et al., 2009). Firms harness tools such as decision support, executive information systems, online analytic processing and data mining in transforming data into information that can inform business decisions and create value. To effectively transform supply chain data into useful insights, firms need to have high levels of data assessment capability.

Data evaluation capability refers to the ability of firms to perceive, organize and process supply chain data gathered from their suppliers and customers. Research shows that human cognition is a key determinant on how organizations respond to external stimuli (Watts et al., 2009). Apart from technology tools and systems which can aid transformation of raw data into useful information that can inform business decisions, human/managerial intervention is a necessity in regard to interpreting data, and creating an enabling platform that leverages insights provided. This human element is important for enhancing the firm's sensing capability and performance as well (Kohli & Jaworski, 1990; Heusinkveld et al., 2009). Underpinning data evaluation capability are organizational and cultural factors. These involve creation of an organizational culture that supports the willingness and commitment to explore different or new perspectives, and other types of insights that are different from what the organization is used to (Cohen & Levinthal, 1990; Szulanski, 1996).

The validated model (Fig 2) does not however assume that supply chain sensing capability directly impacts firm performance. Specifically, the model shows how the firm's ability to engage in the activities of upstream information sharing, downstream information sharing, ensuring information quality, and effective use of technology serves as underlying mechanisms in harnessing the supply chain for sensing. The model proposes that engaging in these SCSC activities should lead to improved firm performance through the potentially mediating effects of sensing capability and reconfiguring capability.

Previous research suggests that time lag is an important contingency in the development of capabilities, and how such capabilities influence firm performance (D'Aveni, Dagnino, & Smith, 2010; Romme, Zollo, & Berends, 2010). Wu, et al. (2010) elaborated on this assertion by identifying time as one of the key features of organizational capabilities. They state that "organizational capabilities are tacit processes that emerge gradually over time" (Wu et al., 2010, p. 724). Research also indicates that time is a key attribute in the development of DC (Romme et al., 2010), and deployment of DC (Zott, 2003). In their conceptualization of DC, Romme et al. (2010, p. 1274) state that "dynamic capability... accumulate or deplete over time as a result of resource in- and outflows related to processes of building, integrating or reconfiguring". Consequently, this study acknowledges that time lags may exist between the processes of sensing, seizing, and reconfiguring; which may pose potential concerns in how SCSC ultimately influences firm performance.

5.2 Summary, conclusion and future studies

Our preliminary theoretical model (Fig 1) was a foundation for empirical studies and validation through case studies with managers in eight manufacturing firms in NSW Australia resulting in a refined validated model (Fig 2) which is explained above. In future studies, the refined validated theoretical model may be tested quantitatively through a much larger survey of managers to further test it as to its robustness, generalisability, and empirical validity. Nonetheless, as competition intensifies in the business environment, firms will have to develop new means of addressing uncertainties in a timely manner. This challenge remains a key concern for firms in the current business world. While there has been advances in DC research to understand how firms can sustain competitive advantage, deep understanding of the underpinning micro-foundations through which the DC processes are developed remains elusive. This study presents a new basis for understanding sustaining competitive advantage by exploring how the firm can explore its upstream and downstream supply chain to enhance its sensing capability-which is the primary and fundamental process of DC development. Information exchange across the supply chain could become a key source of competitive advantage, through provision of valuable insights which are unique to firms within their supply chain.

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