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IMPACT OF BIG DATA AND PREDICTIVE ANALYTICAL CAPABILITY ON SUPPLY CHAIN PERFORMANCE IN AUTOMOTIVE INDUSTRY

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Abstract:

Scholars acknowledge the importance of big data and predictive analytics (BDPA) in achieving business value and firm performance. However, the impact of BDPA on supply chain (SCP) under the mediation of supply chain agility and supply chain visibility while absorptive capacity and organizational culture are the moderators has not been thoroughly investigated. To address this gap, this paper draws on knowledge-based view and dynamic capability view. It conceptualizes BDPA effect on SCP and identifies the influence of SC agility and SC visibility under the mediation effect of absorptive capacity and organizational culture on SCP. Survey questionnaire emailed to automotive industries managerial level employees related to supply chain. Theoretical and managerial level implications are discussed.

Introduction

Interest in the concept of supply chain management has steadily increased since the 1980s when companies saw the benefits of collaborative relationships within and beyond their own organization. Supply chains were originally defined in the book of Handfield and Nichols (1999) as "encompassing all activities associated with the flow and transformation of goods from raw materials through to the end user, as well as the associated information flows". Supply chain management was then further defined as "the integration of supply chain activities through improved supply-chain relationships to achieve a competitive advantage". Quinn (1997) defines the supply chain as "all of those activities associated with moving goods from the raw-materials stage through to the end user. This includes sourcing and procurement, production scheduling, order processing, inventory management, transportation, warehousing, and customer service. Importantly, it also embodies the information systems so necessary to monitor all of those activities."

In addition to defining the supply chain, several authors have further defined the concept of supply chain management. As defined by Ellram and Cooper (1993), supply chain management is "an integrating philosophy to manage the total flow of a distribution channel from supplier to ultimate customer". Monczka and Morgan (1997) state that "integrated supply chain management is about going from the external customer and then managing all the processes that are needed to provide the customer with value in a horizontal way". RR Lummus (1999) defined as supply chain management coordinates and integrates all of supply chain activities into a seamless process. However, there has been an increasing attention placed on the performance of the Supply chain (BM. Beamon 1998). Data collected by the Supply Chain Council (1997) indicates that excellent supply chain performance can lower cost by up to 7% and enhance cash flow by more than 30%.

Over the last years, supply chain management (SCM) has emerged as a prime factor to increase organizational effectiveness and for accomplishment of organizational goals. With the considerable development in SCM, both researchers and practitioners are interested in measuring supply chain performance. Supply chain performance (SCP) is defined as the performance of the various processes included within a firm's supply chain (Srinivasan et al., 2011). In recent years, the SCP measurement has been receiving incessant attention from the scholars as well as practitioners. Overall, the seamless flow of integrated information allows for improved SCP in terms of timely delivery, optimum inventory levels and cost effectiveness (Whitten et al., 2012) eventually affects the overall organizational performance. Supply chain disruptions can impact supply chain performance adversely when measured in terms of lost sales and damaged reputations.

Information technologies are often viewed as enablers for supply chain integration (Chae et al. 2005). According to Handfield and Nichols (1999) information technology comprises information that business creates and uses as well as broad-spectrum of increasingly convergent and linked technologies that processes the information. The rapid development that is taking place in the information technology has changed the competition territory in many industries.

Among various technology innovations, big data characterized by volume, variety, velocity and value (Chen et al., 2013) plays a central role. Wamba et al. (2015) further characterized it as 5 Vs: volume, velocity, variety, veracity and value. Here volume refers to the large amount of data generated. From a statistical point of view, the results of data analyses are statistically highly reliable with high sample size. With the recent advances in the technology, the rate at which data is generated is fast. This characteristic of the data is referred as velocity. Variety refers to the mix of different data sources in different formats: unstructured data, semi-structured data and structured data. Veracity refers to the inherent unpredictability of some data requires analysis of large data to gain reliable prediction and value refers to the extent to which one can derive economically worthy insights or benefits through extraction or transformation. Wong (2012) and Manyika et al. (2011) states that big data provides direction for firms to boost supply chain operations and innovations.

The power of big data is usually related to predictive analytics that uses statistical knowledge to forecast future events based on the assumption that what has occurred in the past may have influence on future events (Oztekin, 2017). After acquiring the raw data from the various sources, cleaning, integration, and other steps are followed to make it ready for further analyses using appropriate predictive techniques. Analyzing big data using predictive techniques may offer many advantages and benefits (Chen et al.,2014). Big data & predictive analytics (BDPA) may be defined as an organizational capability which uses statistical knowledge to forecast future events based on the assumption that what has occurred in the past may have influence on future events (Gupta and George, 2016; Dubey et al. 2017).

Supply chains are configurations of firms that work together in the network which constantly needs to improve their operations and capacity, either by suppliers or customers. The concept of agility has experienced increasing attention in production and supply chain management research due to its importance for managerial practice. Supply chain Agility (SCA) can be considered a dynamic capability that enables firms to adapt to changes and provide quick responses throughout the

entire supply chain (Lee, 2004; Lin et al., 2006; Swafford et al., 2006). SCA thus extends beyond a single firm and involves alignment with major customers and suppliers. Recent work on SCA includes the studies by Braunscheidel and Suresh (2009) and Blome et al. (2013). While the former investigates the relationship between integration and SCA, the latter reviews empirical SCA studies and examines the link between SCA and operational performance.

Supply chain decision makers more often seek to increase their visibility of both demand and supply information, where *visibility* is defined by the availability (currency) and quality (accuracy, usefulness) of information (Zhou and Benton Jr. 2007, Barratt and Barratt 2011, Williams et al. 2013). Visibility is the ability of the supply chain to enable access and sharing of information across the supply chain partners (Lamming et al., 2001).Supply chain visibility is a desired organizational capability to moderate risk resulting from supply chain disruptions (Juttner and Maklan, 2011). Consumer increasingly wants to know more that where and how the product they purchase are being made. To create clarity requires a company to gain visibility into its supply chain and disclose information to consumer.

Likewise, Absorptive capacity (AC) is related to a firm's ability to recognize the value of new information, assimilate it, and apply it to commercial ends (Cohen and Levinthal, 1990). Absorptive capacity, which enables firms to determine, gather, analyze, comprehend, and creatively use the external information (Lane et al., 2006), contributes to management in the creation of loyalty and satisfaction in customers (Tzokas et al.,2015). One of the important elements to harmonize all the resources and capabilities of the company with innovation is organizational culture (Aquilani, Abbate, & Codini, 2017). Dubey et al. 2017 suggest that firms which invest in right talent and build knowledge sharing culture are more successful in building Big Data and Predictive Analytics capability which may help eliminate complexities resulting in supply chains due to information asymmetry resulting from poor visibility. The authors argued that dynamic capabilities are unique to every firm and may be built upon organizational culture or history (Teece et al., 1997).

The BDPA has received wide recognition among scholars as an organizational capability which may help to improve the supply chain performance (Papadopoulos et al. 2017). Gunasekaran et al. (2017) argue that BDPA, as an organizational capability, may help to improve supply chain visibility and unleash powerful insights to understand the current situation and predict future possibilities. Although literature indicates that big data and predictive analytics (BDPA) convey a distinct organizational capability, little is known about their performance effects in particular contextual conditions (inter alia, national context and culture, and firm size).

The relationships between both dynamic capabilities (SCA and Absorptive capacity) and their impact on firm performance are less studied. Although several scholars have pointed out the importance of knowledge to manage supply chains (Yusuf et al., 2004; Hult et al., 2004; Fugate et al., 2009; Marra et al., 2012), other scholars indicate the need to analyze the influence of AC on several characteristics of a supply chain such as agility (Yang, 2014; Gligor et al., 2015).

The purpose of this quantitative study is to investigate effect of SCA and SCV on BDPA and Supply chain performance and to understand the roles of AC and OC as moderators on the relationship between BDPA, SCA and SCV. This study aimed to produce a greater understanding of SCA and SCV's impact on BDPA and SC performance by manufacturing industries perspective using Dynamic Capability view an extension of the resource-based view (RBV) (Hitt et al., 2015) and Knowledge base view. The DCV explains a firm's competitive advantage in changing environments (Teece et al., 1997). Hence, the DCV may be defined as the firm's ability to integrate, build and reconfigure internal and external competences to respond to rapid changing environments (Teece et al., 1997).

Theoretical Background

Dynamic Capability View

In the past decade the Dynamic Capability (DC) perspective arose as one of the most effective theoretical lenses for the strategic management field (Schilke, 2014), attracting the interest of scholars not only in business, but also in the IT management field (Helfat et al., 2009; Protogerou, Caloghirou, & Lioukas, 2012). Although the literature has a broad range of definitions for DC, one of the seminal papers defines DC as "the ability to integrate, build, and reconfigure internal and external competencies to address rapidly-changing environments" (Teece et al., 1997). Teece (2007) defines agility as a higher-order dynamic capability that emerges over time, generally defining agility as a capability with which firms can identify and respond to environmental threats and opportunities and quickly adjust their behaviors (Goldman et al.1995; Sambamurthy, Bharadwaj, & Grover, 2003). Achieving agility demands processing a large and varied amount of information (Goldman et al. 1995). This process is possible with BDA applications.

Akter et al. (2016) argue using DCV logic that BDPA can provide competitive advantage to an organization in highly dynamic situation when due to lack of transparency the organization, despite of having stock of strategic resources, often fails to translate into desired competitive advantage. Liu et al. (2010) argued that OC can impact managers' ability to process information, rationalize, and exercise discretion in their decision-making processes. It is suggested, therefore, that firms that have the listed positive attributes of organizational culture (Adhocracy) are better suited to handle the situation than those with the negative attributes (Hierarchy).

AC becomes a firm's dynamic capability that it is valuable and difficult to imitate by competitors because it depends heavily on the trajectory and prior knowledge of each firm (Volberda et al., 2010). This capability becomes then something scarce, difficult to imitate and replace that contributes to obtain competitive advantages ahead of competitors. Thus, firms with a high AC may react much more effectively to customer's needs with new or adapted products, at the same time that they may improve their organizational routines and management practices which contributes positively to enhance firm performance (Lane et al., 2006; Dobrzykowski et al., 2015).

Wei and Wang (2010) define SCV as the capability to sense changes in the market, gain knowledge from partners, manage SC relationships, and achieve goal congruence in the SC. According to Lee et al., 1997, 2000; Simatupang& Sridharan, 2002 visibility is a critical capability for improving supply chain performance.

Knowledge Base View

The possession of knowledge resources gives the firm basic foundations to renew or reconfigure its resource base and to build dynamic capabilities (Wu, 2006), such as organizational agility. KBV theory can help to conceptualize the performance effects of IT investments (Pavlou et al., 2005). KBV states that a firm's knowledge resources are unique and inimitable and that the firm's primary function is to leverage them into productive outcomes (Grant, 1996; Nonaka, 1995). Management studies use this theory (e.g, Nieves & Haller, 2014), as do studies in IT fields (e.g., Sher & Lee, 2004) to understand the role of knowledge management in the creation of DC.

The positive impact of information systems on supply chain performance is widely acknowledged by many researchers (Fawcett and Clinton 1996; Williams et al. 1997; Stank et al. 1999; Lambert and Cooper 2000; Lau and Lee 2000; Brandon-Jones et al. 2014). Timely and accurate information on inventories and stocks provided by logistics information systems help organizations minimize the inventory quantities and strategically allocate storage locations and logistics hubs in an optimum way (Chen et al. 2009).

CôrteReal et al. (2017) empirically tested the KBV and dynamic capabilities to understand the role of BDA in the creation of organizational agility. The authors discovered that BDA could create agility through knowledge management, which consequently affects organizational processes and competitive advantage. The

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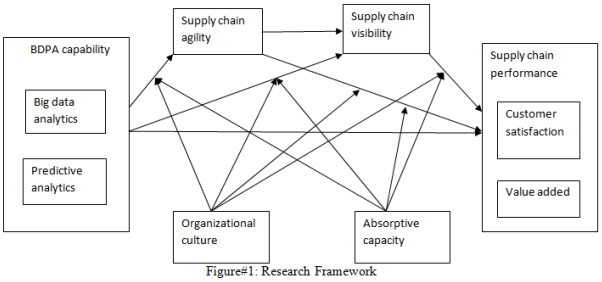
application of the KBV in the literature is vast. Considering big data studies, the theory is important in fomenting discussions about the knowledge necessary to manipulate a massive quantity of data filtering, analysis and other elaborate actions and how to create this knowledge, thus creating value and competitive advantage for the organizations. So, based on these arguments the proposed framework of research is:



Figure#1: Research Framework

Hypothesis Development

Relationship between Big data and Predictive Analytics and SC performance

LaValle et al. (2011) noted that top-performing organizations use analytics five times more than low performers. Raffoni et al. (2018) argue that big data analytics, if used cautiously, can help the organization to achieve better performance. Gunasekaran et al. (2017) noted that the big data and predictive analytics capability have positive impact on supply chain and organizational performance. The BDPA has received wide recognition among scholars as an organizational capability which may help to improve the supply chain performance (Papadopoulos et al. 2017). Minelli et al. (2012) define big data as the next generation of data warehousing and business analytics for delivering a higher level of performance.

H1- Big data has positive impact on Customer satisfaction.
H1a- Big data has positive impact on Value added services.
H1b- Predictive Analytics has positive impact on Customer satisfaction.
H1c- Predictive Analytics has positive impact on Value added services.

Relationship between BDPA and SCA

Swafford et al. (2008) found that IT capability has positive effect on SCA. Gunasekaran et al. 2017 argue that supply chain disruptions have negative effects and agile supply chain enablers were progressively used with the aid of big data and business analytics to achieve better competitive results. The need for Big data analytical capability is heightened by volatile and complex task environments, where high levels of uncertainty make effective planning and decision making difficult. Choi et al. (2017) argue that big data has significant effects on operations management practices. Adoption of BDA technologies could improve organization capabilities in today's rapidly changing dynamic market environment (Meredith et al., 2012). BDPA Organizations are not only harnessing and analyzing big data for improved transparency and decision-making, but also for improving collaboration (Waller and Fawcett, 2013; Schoenherr and Cheri, 2015; Hazen et al., 2014; Wang et al., 2016a; Kache and Seuring, 2017). Gold et al. (2010) observe that collaboration among partners in supply chains is used to meet sustainability goals, and address environmental (Vachon and Klassen, 2008), social, and governance issues (Pagell and Wu, 2009).

H2- Big data is positively associated with Supply Chain Agility.
H2a- Predictive analytics is positively associated with Supply Chain Agility.

Relationship between SCA and SC performance

Eckstein et al. (2015) view SCA as a dynamic capability that not only helps to meet customers' demand but also helps to enhance the firm's profitability. Whitten et al. (2012) tested empirically, using a survey of 132 respondents that SCA along with other capabilities (i.e supply chain adaptability and supply chain alignment) has a positive impact on supply chain performance and supply chain performance further positively affects organizational performance. Blome, Schoenherr and Rexhausen (2013) put forward the idea that supply chain agility is a dynamic capability able to positively influence the operational performance of the firm.

H3- Supply Chain Agility is positively associated with Customer satisfaction.
H3a- Supply Chain Agility is positively associated with value added services.

Relationship between BDPAC and SCV

From the RBV perspective, capabilities are performance enhancement constructs (see Newbert, 2007; Brandon-Jones et al., 2014). The information systems literature broadly conceptualizes *analytics capability* as a technologically enabled ability to process large *volumes* and *varieties* of data with the *velocity* required to gain relevant insights (chen et al. 2012, McAfee and Brynjolfsson 2012), thereby enabling firms to gain competitive advantages (Kiron and

Shockley 2011, Lavalle et al. 2011). Barratt and Oke (2007) have conceptualized supply chain visibility (SCV) as a capability that helps an organization to generate sustainable competitive advantage. Supply chain visibility is achieved through developing external lateral relations with customers and suppliers. However, firms are finding advantages in making real-time decisions through insights gained from disparate sources of data and analyzed using powerful, automated tools. To reduce information lead times and to improve information currency, firms need supporting organizational infrastructure and processes that enable them to quickly acquire, process and analyze data. The insights gained through increased *information processing capacity* can reduce uncertainty, especially when markets are volatile and operational tasks are complex (i.e., highly interdependent). These basic principles have found renewed relevance, considering the emergence of vastly improved data availability (e.g., "big data") and computing power. Srinivasan and Swink (2017) noted that supply chain visibility is a prerequisite for building data analytics capability and vice versa. Supply chain visibility and BDACs are complementary, in the sense that each supports the other (Gunasekaran et al. 2017). Srinivasan and Swink (2017) argue that organizations that invest in building analytics capabilities are likely to invest in visibility, because visibility provides the raw data upon which analytics systems and process operate.

H4- Big data is positively associated with Supply Chain Visibility.
H4a- Predictive analytics is positively associated with Supply Chain Visibility.

Relationship between SCV and SC performance

The missing link in many research studies examining the role of information sharing and improved performance is visibility (Barratt & Oke, 2007). Bartlett et al. (2007), the levels of visibility have ranged from opaque (where no information is shared) to translucent (sharing partial information) to transparent (sharing information that leads to knowledge and collaborative abilities). Visibility is assessed in relation to the key performance criteria of each business function in three dimensions (cost, quality, and delivery). Wei and Wang (2010) propose to measure the effectiveness of SCV based on improved market learning and trust-building capabilities, while Caridi et al. (2014), McIntire (2014) and Lee and Rim (2016) measure the effectiveness of SCV by the extent to which visibility is used to automate decision making, or reduce the performance gap in business processes.
According to McIntire (2014) SCV is assumed to have a direct impact on business performance and the effectiveness of SCV is measured by changes in overall business outcome. MasonJones and Towill (1998; 1999) demonstrated that "information enriched" supply chains perform significantly better than those that do not have access to information beyond their corporate boundaries. Further, exchanging ideas in supply chain meetings can clarify many causal ambiguities for producing supply chain performance, and therefore result in adaptive adjustments to the existing configuration or more radical reconfiguration for more fundamental changes (Zollo & Winter, 2002).

H5- Supply Chain Visibility is positively associated with Customer satisfaction.
H5a- Supply Chain Visibility is positively associated with Value added services.

Mediating role of SCA and SCV

SCA has been analyzed as a mediating effect in a few studies. For example, Vickery et al. (2010) tested the mediating role of agility in the relationship between antecedents (supply chain information technology and supply chain organizational initiatives) and firm performance. Agility was also posited by Swafford et al. (2008) as a mediator linking the effect of information technology integration to competitive business performance. Similarly, Blome et al. (2013) found a mediating effect in the relationship between supply and demand side competence and performance, and Danese and Romano (2013) found that a fast supply network structure influences the relationship between customer integration and efficiency performance. A comprehensive perspective on supply chain agility needs to include both visibility and velocity dimensions and progress is needed in both domains to achieve a higher level of supply chain agility. This perspective is also supported by Christopher and Peck (2004). Visibility captures organizational vigilance to state of affairs and events taking place in the supply chain, which can range from simple monitoring of inventory levels to assessment of the probability of plant shutdowns due to inclement weather. It captures the scope of events across which an organization needs to be vigilant (Braunscheidel and Suresh, 2009; Chiang et al., 2012; Tallon and Pinsonneault, 2011). Velocity captures the time dimension, and subsumes the quickness in recognition of an event and the rapidity of response. Exchanging demand information from downstream to upstream SC echelons reduces uncertainties in the inter-organizational relationship and, accordingly, enhances trust between the participants (Kim et al., 2011, p. 668).

H6- Supply Chain Agility positively mediates the relation between big data and predictive analytics and Supply Chain performance.
H6a- Supply Chain Visibility positively mediates the relation between big data and predictive analytics and Supply Chain performance.

Moderating role of Absorptive capacity

Cohen and Levinthal (1990, p. 128) defined Absorptive capacity (AC) as ''the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends is critical to its innovative capabilities". Tsai (2014) proves the moderating influence of the ACAP in the international expansion of companies from emerging economies in his study of 200 Taiwanese companies. The contributions where the AC is used as a moderating variable is verified in Kohlbacher et al. (2013), who explore the impact of AC on the innovation in a business cluster in Central Europe and Aljanabi et al. (2014) relate the organizational factors of support to a group of IT companies from Kurdistan with technological innovation. Recently, absorptive capacity receives extensive consideration in supply chain research for its effects on supply chain collaboration (Zacharia et al. 2011) and capability development (Patel et al. 2012; Setia and Patel 2013). Meanwhile, absorptive capacity is considered a critical dynamic capability that enhances operational efficiency and innovation in a buyer-supplier relationship setting (Sáenz et al. 2014; Whitehead et al. 2016)

H7- Absorptive capacity moderates the relationship between BDPA capability and Supply chain performance.
H8- Absorptive capacity moderates the relationship between big data and supply chain agility.
H8a- Absorptive capacity moderates the relationship between big data and supply chain visibility.
H9- Absorptive capacity moderates the relationship between predictive analytics and supply chain agility.
H9a- Absorptive capacity moderates the relationship between predictive analytics and supply chain visibility.
H10- Absorptive capacity moderates the relationship between supply chain agility and Supply chain performance.
H11- Absorptive capacity moderates the relationship between supply chain visibility and Supply chain performance.

Moderating Role of Organizational culture

The Competing Values Framework model proposed by Cameron and Quinn (1999) identifies four types of organizational culture that the company can apply:

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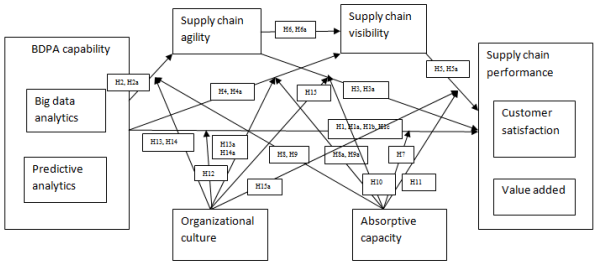
adhocracy, clan, market and hierarchy. These four cultures are configured in two dimensions related to flexibility, using two dimensions: flexibility versus control and external versus internal focus. Flexibility orientation allows organization to be creative and risk-taker and open for embracing changes in the environment. In contrast, control orientation emphasizes uniformity, coordination, efficiency, and close adherence to rules and regulations.

The second dimension, the internal–external axis, concerns a focus on activities occurring within or outside the firm. An internal focus emphasizes smoothing activities and alliances, while an external focus stresses competition and environmental differentiation. Liu et al. 2010 check the effect of organizational culture and institutional theory to investigate how institutional pressures motivate the firm to adopt Internet-enabled Supply Chain Management systems (eSCM) and how such effects are moderated by organizational culture. In the current research, we adopt the framework of flexibility-control orientation in the Competing Values Model (CVM) proposed by Quinn and Rohrbaugh (1983).

H12- Organizational Culture moderates the relationship between BDPA capability and SC performance.
H13- Organizational Culture moderates the relation between big data and Supply Chain Agility.
H13a- Organizational Culture moderates the relationship between big data and Supply Chain Visibility.
H14- Organizational Culture moderates the relationship between predictive analytics and Supply Chain Agility.
H14a-Organizational Culture moderates the relationship between predictive analytics and Supply Chain Visibility.
H15-Organizational Culture moderates the relationship between supply chain agility and Supply chain performance.
H15a-Organizational Culture moderates the relationship between supply chain visibility and Supply chain performance.

Hypothetical model



Research method

For the purpose of data collection, an online survey would be conducted from Pakistan related to automotive industries. Well structured questionnaire would be used as a research instrument to collect information with respect to the related variables given in the proposed framework. Population of the study would include all companies/organization from automotive sector. Sample size would be calculated from the final list of population by employing random sampling.

Dubey et al. 2018 used WarpPLS 5.0 software to test the model. The software employs the partial least squares (PLS) structural equation modeling method or in short form PLS SEM (Kock, 2014, 2015). PLS is a prediction-oriented tool which allows researchers to assess the predictive validity of the exogenous variables (Peng and Lai, 2012). Scholars argue that PLS is better suited for explaining complex relationships as it avoids two serious problems: inadmissible solutions and factor indeterminacy (see, Peng and Lai, 2012; Henseler et al. , 2014; Moshtari, 2016; Pratono, 2016; Akter et al., 2017; Martí-Ballester and Simon, 2017; Dubey et al., 2018). Martinez-Sanchez and Lahoz-Leo, 2018 to test the mediating effect of SCA in the relationship between AC and firm performance, used the methodology proposed by Baron and Kenny (1986) with a focus of structural equations modelling (SEM), in which a structural equation model is adjusted in four successive steps.

Srinivasan and Swink (2017) used the correlation matrix for the constructs in the study. They used confirmatory factor analysis (CFA) to validate the measures used in this study. In addition to the above tests, they investigated bivariate correlations between the independent variables and corresponding dependent variables to check for outliers. This study is tested by using partial least squares structural equation modelling (PLS-SEM). As described in many current literature (e.g., Chin et al. (2003); Hair et al. (2009); Hair et al. (2011); Tenenhaus et al. (2005)), PLS-SEM is considered a good alternative to and advantageous in comparison to the covariance-based structure equation modelling method. The results would be calculated with satisfied respondent rate. Data analysis would be conducted by employing SPSS software.

Theoretical and Practical implications

This study will contribute to both theory and practice in several ways. This study will be conducted by using knowledge base view as it is less studied in the perspective of BDPA. This study will analyze the internal and external capabilities impact on SC performance. This study will examine the application of BDPA can enhance the performance of the firm which is very useful practical insight for business managers. Lastly this study will provide actionable information to the practitioners and policy makers to make sensible decisions in multiple areas, such as strategic management, supply chain management and marketing about the connectivity and information sharing with their customers and supply partners. The cost-benefit analyses of investment related to BDPA implementation. The demand and prediction related to the products and trends prevail in the economy and target market

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