The mediating role of supply chain management on the relationship between big data and supply chain performance using SCOR model

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A B S T R A C T

Adopting the Supply Chain Operations Reference (SCOR) model, this study aims at investigating the impact of big data (volume, velocity, variety, veracity, and value) on supply chain performance through the mediating role of supply chain management (plan, source, make, deliver, and return) assuming four hypotheses. Data were collected using a questionnaire from managers of food processing companies. The results showed that big data affected supply chain management significantly and positively, which in turn affected supply chain performance significantly and positively. In addition, big data exerted a significant and positive impact on supply chain performance. Based on these links, it was found that supply chain management mediated significantly the effect of big data on supply chain performance. The study contributes to the literature showing that big data plays a pivotal role in improving supply chain performance and supply chain performance from the SCOR model perspective is critical for the relationship between these two constructs.

1. Introduction

Nowadays, big data (BD) becomes a principal trend in supply chain management (SCM). Globally, BD business is expected to grow to about USD 230 billion by 2025 (Lee & Mangalaraj, 2022). Therefore, BD has gained a great attention from many companies all over the world. BD has numerous effects on both supply chain management and supply chain performance. Using BD solutions is very important to deal with large amounts of structured and unstructured data generated in a speedy manner, collected from various sources, to generate beneficial knowledge (El-Kassar & Singh, 2019; Charles & Gherman, 2013; Ylijoki & Porras, 2016; Demchenko, De Laat & Membrey, 2014; Jewell et al., 2014; Han, John & Zhan, 2017).

The literature on the effects of BD has indicated that BD has significant effects on both SCM (Raman et al., 2018) and SCP (Ibrahim & Hamid, 2014). However, little studies have used the SCOR model to assess SCM. Therefore, this study aims at investigating the impact of BD on SCM and SCP as well as the effect of SCM on SCP to test the mediating role of SCM. The contribution of this study is to examine the effects of BD on SCM and SCP in the absence of previous studies carried to achieve this aim. Moreover, the study uses the SCOR model, which consists of plan, source, make, deliver, and return to measure SCM.

The reminder of the study is structured as follows. Section 2 presents a literature review on BD, SCM, and SCP and their hypothesized relationships. Section 3 contains research methodology in which research sample, conceptual model, measurements, as well initial tests such as validity and reliability were provided. Section 4 shows the results of the study as revealed through hypothesis testing. Discussion, conclusion and implications are unfilled in section 5. Finally, study limitations and future research directions are reported in section 6.

2. Literature review

2.1 Big Data

BD refers to a large volume of structured and unstructured data that cannot be managed using typical data means used to acquire, access, analyze, and apply data (Raman et al., 2018; El-Kassar & Singh, 2019; Alwan et al., 2022). It has been defined as large data sets gathered from various sources and therefore cannot be captured and processed or visualized using conventional information technologies (Charles & Gherman, 2013). De Mauro et al. (2015: 103) defined big data as "the information assets characterized by such a high volume, velocity and variety to require specific technology and analytical methods for its transformation into value". It was noted that most definitions of BD were built on its five characteristics: volume, velocity, variety, veracity, and value (Demchenko, De Laat & Membrey, 2014; Zhang & Lv, 2021), which were deemed as BD dimensions.

Reviewing the extant literature revealed that BD has five key dimensions, i.e., volume, velocity, variety, veracity, and value (Charles & Gherman, 2013; Ylijoki & Porras, 2016). Therefore, big data solutions should process large amounts of data, rapidly arrived data, structured and unstructured data, and validate a great volume of rapidly arrived data (Jewell et al., 2014). Firstly, data volume refers to the huge amounts of data generated by a company every second (Jewell et al., 2014). It was described as escalating quantities of data (Ylijoki & Porras, 2016) measured by storage units like gigabytes (Han, John & Zhan, 2017). Such amounts increase based on transactions storage and other data types such as data acquired from social media. One important issue of data high volume is how to create value from data using analytics (Verma et al., 2016). Secondly, data velocity represents the speed of data generation (Jewell et al., 2014). It refers to the need to acquire and analyze speedy data in real-time (Ylijoki & Porras, 2016). As data flows at unmatched speed, it should be processed in a timely mode. A quick response to data speed represents a main challenge for organizations (Verma et al., 2016).

Thirdly, data variety encompasses both structured and unstructured data collected from different sources (Jewell et al., 2014; Ylijoki & Porras, 2016). Examples of these sources include social media posts, text documents, audio, video, financial transactions, emails, and data extracted from business applications (Verma et al., 2016). Fourthly, Data veracity refers to data uncertainty because of factors like inconsistent data and incomplete data (Debattista et al., 2015). So that, users who trust consistent and complete data can use it in making their decisions (Jewell et al., 2014). Assiri (2020: 6) defined data veracity as "a process of assigning markers of quality, and then determining the quality and correctness of a data set"; as well, the author added that it signifies data quality. Finally, data value symbolizes extracting knowledge from the available current data (Debattista et al., 2015). For Wamba et al. (2015: 6), data value is "The extent to which big data generates economically worthy insights and or benefits through extraction and transformation". The importance of this dimension is that it translates high volume data into real applications (AlZyadat et al., 2018).

2.2 SCOR-driven SCM

Keywords of SCM definitions as reported in the literature include business activities, business relationships, raw materials, end users, recycling, competitive advantage, logistics, distribution, product design, product development, customer post-delivery support, technology, suppliers, suppliers, wholesaling industry, retailers industry, management efficiency, companies coordination, demand-based management and information sharing (Tan, 2001; Kopczak & Johnson, 2003; Al-Hawary & Al-Jawazneh, 2011; Wisner, Tan & Leong, 2012; Al-Hawary & Abu-Laimon , 2013; Al-Hawary et al., 2017; Al- Quran et al., 2020; Aityassine et al., 2021; Al-khawaldah et al., 2022;). SCM is defined as a multi-firm perspective of boosting management efficiency using initiatives such as Just-in-Time (JIT) or initiatives such as efficient customer response (ECR) to reduce supply chain costs.

The Supply Chain Operations Reference (SCOR) model describes and analyses supply chains using three key techniques: business process modeling, performance benchmarking and analysis of best practices (Georgise, Thoben & Seifert, 2013). The Supply Chain Council recognized the SCOR model as a standard diagnostic tool for SCM (Kamarudin & Nizam, 2022). The benefit of this model is that it allows companies to conduct and improve SCM practices as well as communicate with all supply chain partners (Jamehshooran, Shaharoun & Haron, 2015). The SCOR model consists of five dimensions: plan, source, make, deliver, and return.

The first dimension of the SCOR model (i.e., plan) refers to customer demand assessment using big data analytics and making good decisions using the 4Vs framework (volume, velocity, veracity, and variety) (Raman et al., 2018). "Plan" is concerned with data analysis and market forecasting and involves searching and evaluating suppliers for selection (Delipinar & Kocaoglu, 2016). Planning activities include identifying customer requirements, gathering data on existing resources, balancing customer requirements and available resources to determine the capabilities required, predicting market trends, and

building supply plans to meet market demand (Jamehshooran, Shaharoun & Haron, 2015). As a key process, "plan" consists of three sub-processes: supply chain planning, supply and demand alignment, and inventory management (Mañay, Guaita-Pradas & Marques-Perez, 2022). The second dimension (i.e., source) refers to collecting data from many sources such as sensors and tracking devices as well as using social media to evaluate vendors (Ramanet al., 2018). This dimension is very critical in supporting the first one as it involves handing out buying orders, scheduling distributions, validation and storage of received shipments, price arbitration and supplier appraisal (Jamehshooran, Shaharoun & Haron, 2015). As a procurement process, "source" consists of four sub-processes: strategic sourcing, supplier management, products and services purchase, and logistics management (Mañay, Guaita-Pradas & Marques-Perez, 2022).This dimension allows companies to strength their market competitiveness and improve data quality in addition to making decisions of logistics planning using BD as well as determine the importance of inputs flow and rate suppliers (Ramanet al., 2018). It signifies manufacturing of the goods focusing on production batches and time (Delipinar & Kocaoglu, 2016). Totally, this dimension is concerned with materials conversion and service creation, for example, materials assembly, repair, maintenance, remanufacturing, and recycling (Jamehshooran, Shaharoun & Haron, 2015).

The third dimension (i.e., make) comprises supplier relationships, sales logistics, and development of supply chain infrastructure (Mañay, Guaita-Pradas & Marques-Perez, 2022) while the fourth dimension, "deliver" refers to a process used to provide goods and services to meet customer demand (Delipinar & Kocaoglu, 2016). It relates to determining delivery need, scheduling and shipment scheduling (Jamehshooran, Shaharoun & Haron, 2015) and encompasses storage activities, customer and business partner management (Mañay, Guaita-Pradas & Marques-Perez, 2022). Finally, the fifth dimension (i.e., return) signifies activities such as handling reverse stream of products returned from different customers (Jamehshooran, Shaharoun & Haron, 2015). "Return" process consists of three sub-processes: receiving reverted goods, repair, as well as customer expectation management (Mañay, Guaita-Pradas & Marques-Perez, 2022), in addition to reverse logistics (Bayir et al., 2022).

2.3   SCP

Supply chain covers three basic proportions: service, speed, and assets; service in this regard refers to the ability to satisfy customer demand through on-time delivery of personalized products, while speed signifies tracking responsiveness, and assets implies commercial values such as cash and inventory (Hausman, 2004). Consequently, SCP represents supply chain characteristics utilized to meet the requirements of ultimate customers such as on-time delivery, supply chain capacity, inventory management and responsiveness (Huan et al., 2004). In their study on customer integration, information sharing, and SCP, Tang et al. (2022) measured SCP using four items related to customer query time, range of services, service flexibility, service delivery performance, and post-process services. Gawankar et al. (2020) cited several measures of SCP such as market performance, partnership quality, innovation, responsiveness to customers, flexibility of supply chain resources, and supply chain quality.

2.4   BD and SCM

BD has been utilized in business functions such as marketing and SCM (Lee & Mangalaraj, 2022). Several benefits of big data analysis were reported in the literature such as enhancement of SCM decision-making, improvement of SCM processes, and SCM cost reduction (Lee & Mangalaraj, 2022), generating ideas for new product development, choosing suppliers, detecting and explaining customer behavior, forecasting costs via analyzing changes in prior purchases and pricing (Talwar et al., 2021). In their study on multinational companies from the USA, Asia, Europe, and Australia, Raman et al. (2018) found a positive association between big data and SCM. Therefore, the following hypothesis was presented:

H₁: *BD exerts a significant positive impact on SCM.*

2.5   SCM and SCP

The positive effect of SCM is well documented in the literature. Collecting data from managers in the Malaysian industrial sector, Sukati et al. (2012) found that SCM practices had a significant effect (i.e., customer relationship, strategic supplier partnership, and information sharing) on SCP. Using the SCOR model as an independent variable and SCP as a dependent variable, Kamarudin and Nizam (2022) found a significant impact of all dimensions of the SCOR model (plan, source, make, and deliver) on SCP. Similarly, a study carried out using a sample of supply chain managers in large manufacturing companies in Sudan, Ibrahim and Hamid (2014) indicated that SCM practices (supply chain integration, information sharing, customer and delivery management, supplier management, and responsiveness speed) had significant effects on SCP. Therefore, it was assumed that:

H₂: *SCM exerts a significant positive impact on SCP.*

2.6   BD and SCP

BD collected from the company and its external environment help the company make numerous enhancements as well, BD is used by managers to make decisions and manage operations, which means enabling a company to improve its operational efficiency (Bag et al., 2020). In terms of the relationship between BD and CSP, Fernando, Chidambaram and Wahyuni-TD

(2018) found that BD analytics had a significant impact on service supply chain innovation capability and service CSP. The results of Bag et al. (2020) pointed out that BD analytics capability increased green product innovation and employee development, hence improving innovation and learning performance, which in turn has a significant effect on sustainable SCP. It was expected that BD be positively related to SCP, and in line with the above-mentioned H2; it was also estimated that SCM mediates the effect of BD on SCP. Therefore, the following two hypotheses was suggested:

H3: *BD exerts a significant positive impact on SCP.*

H4: *SCM mediates the impact of BD on SCP.*

3. Methodology

3.1 Research sample

The sample of the study consists of managers of food processing companies. The population covers 15 companies from which 150 managers were chosen. Hence, data were collected using a questionnaire administered to 150 respondents. Totally, 124 responses were received, and 11 were excluded due to incomplete answers. Therefore, 113 responses were used for the purpose of data analysis. Additionally, 17 responses were omitted due to extreme values. That is, the final number of questionnaires used was 96.

3.2 Research model

Figure 1 shows the conceptual model of the study. It consists of three latent variables linked together via four hypotheses (H1, H2, H3, and H4). H1 links big data (BD) to supply chain management (SCM). H2 illustrates the effect of SCM on supply chain performance (SCP). H3 represents the direct effect of BD on SCP, while H4 symbolizes the indirect effect of BD on SCP.
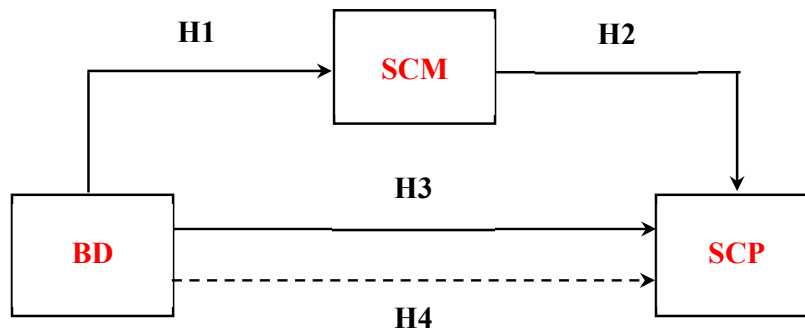

Fig. 1. Conceptual model

3.3 Data measures

BD was measured using five items based on previous studies (e.g., El-Kassar & Singh, 2019). SCM was evaluated using five items on the basis of prior work (e.g. Raman et al., 2018). Five items based on related works (e.g., Tang et al., 2022; Gawankar, Gunasekaranb, & Kamble, 2020) assessed SCP. All items were designed using a 5-point Likert-type scale, where 1 refers to strongly disagree and 5 refers to strongly agree.

3.4 Validity and reliability

Convergent validity is measured through the average variance extracted (AVE) which should be higher than 0.50, which means that the construct explains more than 50% of the variance of the measuring items (Jamehshooran, Shaharoun & Haron, 2015; Al-Hawary & Alhajri, 2020; Al-Abbadi et al., 2021; Al-Hawary & Obiadat , 2021; Tariqa et al., 2022; AlHamad et al., 2022; Ramanet al., 2018). Moreover, discriminant validity is measured following Fornell and Larcker criterion, that is, the square roots of the AVE value for a specific construct should be greater than its correlation with other constructs (Jamehshooran, Shaharoun & Haron, 2015; Al-Hawary & Al-Rasheedy, 2021). Reliability is assessed using Cronbach's alpha, composite reliabilities (CR). Both indices should be greater than 0.70 (Al-Hawary & Al-Syasneh , 2020; Bag et al., 2020; Eldahamsheh et al., 2021; AlTaweel & Al-Hawary, 2021).

Table 1
Results of validity and reliability

Constructs	Items	Loadings	VIF	AVE	rho_A	CR	α	R²
BD	BD1	0.790	2.013					
	BD2	0.800	2.113					
	BD3	0.924	2.970	0.739	0.924	0.934	0.911	-
	BD4	0.889	2.957					
	BD5	0.885	2.219					
SCM	SCM1	0.755	1.680					
	SCM2	0.715	1.610					
	SCM3	0.759	1.600	0.574	0.819	0.870	0.814	0.243
	SCM4	0.805	1.967					
	SCM5	0.752	1.840					
SCP	SCP1	0.807	1.916					
	SCP2	0.850	2.335					
	SCP3	0.840	2.325	0.641	0.878	0.899	0.861	0.431
	SCP4	0.771	1.899					
	SCP5	0.730	1.945					

Results of validity and reliability as described in Table 1 signpost acceptable values of factor loadings ranging from 0.715to 0.889, as well as adequate values of AVEs greater than 0.50, in addition to satisfactory values of rho_A (0.819-0.924), CR (0.870-0.934), and Cronbach's α (0.814-0.911) higher than 0.70. These results indorse validity and reliability.

4. Results

Fig. 2 shows the structural model of the study, which contains three direct links between BD and SCM, BD and SCP, SCM and SCP, in addition to a fourth indirect link between BD and SCP. These links represent the four hypotheses of the study. The results of model fit indexes revealed that Chi-square = 173.327, SPMR = 0.079 (less than 0.08), NFI = 0.875 (close to 0.90). The NFI threshold indicates that the measure should be greater than 0.90, however, this value is underestimated in samples with small sizes such as the sample size of the current study (n=96). On the other hand, rms Theta = 0.187 (close to zero), which indicated a good model fit. Therefore, the model was accepted to test the current hypotheses.
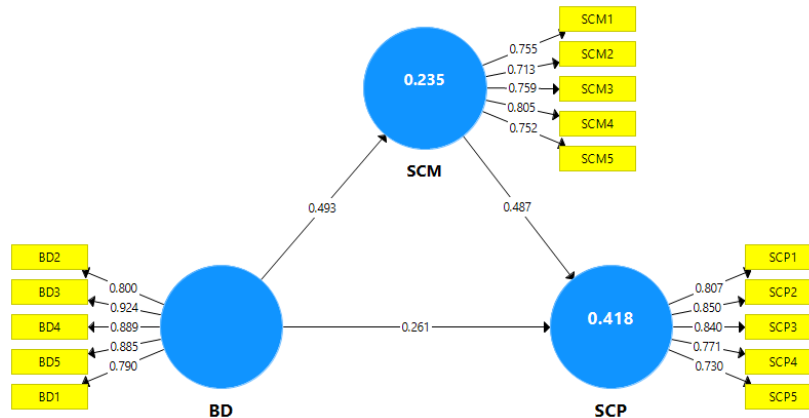

Fig. 1. Structural model

The results as shown in Table 1 indicate that BD has a significant total impact on SCM (β=0.493, t=7.26m P=0.000), which in turn has a significant total impact on SCP (β=0.487, t=6.53, P = 0.000). Furthermore, BD has a significant total impact on SCP (β=0.50, t=6.77, P = 0.000). These results indicate that all research hypotheses are supported.

Table 1
Results of hypotheses testing

Hypotheses			Total Effects			Indirect Effects		
BD	→	SCM	0.493	7.255	0.000	-	-	-
BD	→	SCP	0.501	6.766	0.000	0.240	5.425	0.000
SCM	→	SCP	0.487	6.526	0.000	-	-	-

5. Discussion, conclusion and implications

The aim of this study was to determine the mediating role of SCM in the impact of BD on SCP. The first result pointed out that BD has a significant impact on SCM. Such a result is in line with some previous studies. Lee and Mangalaraj (2022) stated that BD was utilized successfully in SCM in improving SCM decision making as well as SCM cost reduction. Talwar et al. (2021) added that BD helps SCM in generating new ideas for product development, evaluating and selecting suppliers, identifying customer behavior and forecasting costs of changes in prices and purchases. Explicitly, Raman et al. (2018) highlighted a significant impact of BD on SCM.

The second result asserted a significant positive impact of SCM on SCP. Sukati et al. (2012) who found that SCM was positively related to SCP as measured by customer relationship, strategic supplier partnership and information sharing echoed this result. Ibrahim and Hamid (2014) found a significant effect of SCM practices (supply chain integration, information sharing, customer and delivery management, supplier management, and responsiveness speed) on SCP. It should be noted here that SCM in the current study was assessed using the dimensions of the SCOR model, i.e., plan, source, make, deliver, and return. In a study by Kamarudin and Nizam (2022), as evaluated by the SCOR model, dimensions exerted a significant impact on SCP. The third results indicated that SCM has a significant impact of BD on SCP. In the same vein, Bag et al. (2020) illustrated that BD has a significant impact on innovation and learning performance. For Fernando, Chidambaram and Wahyuni-TD (2018), BD analytics is a significant predictor of SCP. As BD has significant impacts on both SCM and SCP and SCM has a significant impact on SCP, the fourth result confirmed that SCM mediated the effect of BD on SCP.

Based on these results it was concluded that both big data and supply chain management are significant predictors of supply chain performance. Therefore, companies are required to utilize big data aspects such as volume, velocity, variety, veracity, and value to enhance supply chain performance. The benefits of big data solutions are that it allows processing large amounts of data, generating data in a speedy manner, collecting structured and unstructured data from different sources such as emails and social media, reducing data uncertainty, and generating worthy data. On the other hand, companies are requested to use the SCOR model to enhance supply chain performance. The SCOR model is used as an analytical instrument to appraise SCM in terms of customer demand valuation, market forecasting, picking suppliers, cooperating with supply chain partners, developing supply plans, using available data to select vendors, managing logistics, improving data quality, building relationships with supply chain partners, distributing products and services in line with customer demand, and handling revert products.

6. Limitation and future research direction

The current study is limited to its hypothesized effects and its sample type and size. Future studies are required to confirm the current results in the same industry, food processing companies and other industries using larger sample sizes and collecting data from SC managers.

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