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Examining the Nexus Between Big Data Analytics Capabilities and Organizational Performance: The Mediating Role of Supply Chain Visibility in Manufacturing Organizations

Shahbaz Sultan [1] Abu Bakar Abdul Hamid [2] Ida Yasin [3] Muhammad Haroon Malik [4] Saqlain Humayun[5]

Abstract: *Big data has revolutionized how businesses operate today, offering unprecedented insights. By harnessing vast amounts of data, companies can optimize performance, enhance decision-making, and drive efficiency. This research examined the relationship between big data analytics capabilities and organizational performance in the context of supply chain visibility based on sample data collected from 400 manufacturing firms operating in Pakistan. The data were gathered from experienced supply chain professionals with the help of a structured questionnaire while Smart PLS 4.0 was employed to evaluate the research model. The research findings indicate that big data analytics capabilities positively affect supply chain visibility and result in improved organizational performance. The study supports the research hypothesis that though big data analytics capabilities may not have a direct impact on organizational performance however, they can both indirectly and positively impact organizational performance when mediated by supply chain visibility. The findings recommend that manufacturing sector organisations should focus on improving supply chain visibility to optimise the benefits of big data analytics capabilities. This research extends the existing literature on big data analytics capabilities from a supply chain perspective, showing how they improve the performance of organisations and hence offer valuable insights to researchers and practitioners.*

Key Words: Big Data, Big Data Analytics, Big Data Analytics Capabilities, Supply Chain Visibility, Organizational Performance

Introduction

Big Data Analytics (BDA) is being adopted in the contemporary digital economy to improve the competitiveness of organizations in various industries and organizational performance (OrgPer). BDA is the practice of utilizing large, diverse, fast-flowing, and complex data to make informed business decisions (Manyika et al., 2011). Numerous industries have transformed their business activities through the adoption of big data analytics technologies by facilitating data-driven decision-making, sparking innovation, and increasing efficiency to achieve improved performance and a sustained competitive edge (McAfee & Brynjolfsson, 2012). However, the key success of organizations in realizing the full potential of BDA is significantly inhibited by their Big Data Analytics Capabilities (BDAC), which are comprised of information technology (IT) infrastructure, managerial competence, and human resources that organizations require to extract meaning from big data (Davenport & Harris, 2007).

The manufacturing industry in Pakistan itself provides a complex yet unique setting to investigate the position of BDA. Being at the forefront of both local and international business landscape it experiences higher levels of competition, complexities within supply chains, and the demands for improvement in operational efficiency and financial results. Since the manufacturing sector forms a large part of Pakistan's economy and its outputs are being exported across different regions of the world, necessary structural upgrades must be done, including the implementation of a BDA solution (Ferraris et al., 2019). However,

[1] PhD Scholar, Putra Business School, Malaysia.
[2] Professor, Putra Business School, Malaysia. Email: abu.bakar@putrabs.edu.my
[3] Associate Professor, Putra Business School, Malaysia. Email: ida@putrabs.edu.my
[4] PhD Scholar, Putra Business School, Malaysia. Email: pbs20204238@grad.putrabs.edu.my
[5] COMSATS University, Pakistan. Email: saqlain.humayun@hotmail.com

▪ **Corresponding Author:** Shahbaz Sultan (pbs20204197@grad.putrabs.edu.my)
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there is a dearth of empirical research that analyses the effects of BDAC on the performance of manufacturing firms in the context of Pakistan. This work thus aims to address this research question; how can BDAC improve Supply Chain Visibility (SCV) for manufacturing organizations to increase supply chain efficiency in the country

BDAC is defined as a firm's both capability and infrastructural readiness to exploit data infrastructure, management processes, and people skills to generate value from the data to enhance business outcomes (Akter et al., 2016). Research has shown that BDAC help organizations work effectively, increase customer loyalty, and make informed decisions (Wamba et al., 2015). When applied to the manufacturing industry, BDAC is most profound about increasing SCV, which is defined by Christopher and Lee (2004) as the capability of the firm to obtain real-time data about its various activities across its supply chain. When implemented in supply chain management, BDA has the potential to disrupt manufacturing firms' opaque value chains thus allowing them to reduce systemic risks and enhance order-winning activities with suppliers and distributors (Kache & Seuring, 2017).

The rationale for this study is anchored on two factors: the increasing significance of SCM in manufacturing firms and the relatively untapped market for the study in emerging countries like Pakistan. The challenges that manufacturing firms experience include volatility in customer demand, supply interruptions, and inadequate scheduling of the production process (Chae, 2015). BDAC has the capability of overcoming these challenges by offering firms real-time information on supply chain activities, hence enabling responsiveness to market forces (Dubey et al., 2019). However, research evidence shows that many manufacturing firms in Pakistan are yet to optimally benefit from BDAC since many of them are still at the initial stage of its implementation (Gawankar et al., 2021). Therefore, the purpose of this research is to discover how BDAC can fill this gap and improve the competitive advantage of the firms operating in the Pakistani manufacturing industry.

Anchored on Resource Based View (RBV) and Dynamic Capability Theory (DCT) theoretical frameworks, this study postulates that BDAC has a direct and positive impact on organizational performance that is contingent on its impact on the degree of supply chain visibility (Barney, 1991; Teece et al., 1997). Based on the RBV, firms obtain competitive benefits by employing valuable, rare, and inimitable resources, including BDAC, which helps firms analyze extensive data sets and provide improved decision-making and innovation (Schoenherr & Speier-Pero, 2015). However, DCT draws attention to dynamic capabilities through which firms can reconfigure both internal and external resources in their rapidly changing environments (Eisenhardt & Martin, 2000). Supply Chain Visibility (SCV) being a firm's dynamic capability, enables the manufacturing firms to adopt flexibly, proactively change, and fine-tune their supply chain strategies to boost organizational performance (Wu et al., 2006).

In the proposed research model, BDAC is postulated to have a direct relationship with organizational performance wherein the firm gains better capacity to process data. Besides, the positive effect of integrating BDA in the supply chains experienced a greater SCV, which acts as a mediator in the relationship between BDAC and performance. They also found that SCV can help manufacturing firms monitor the real-time performance of supply chain activities and use this information to streamline resource management, sort out supplier relationships, and minimize operational hazards (Papadopoulos et al., 2017). This study will fill a gap in the existing literature by offering an empirical analysis that focuses on the impact of BDAC on SCV and organizational performance with special reference to the manufacturing sector in Pakistan.

Theoretical Background and Conceptual Framework

BDA has emerged as a critical enabler for organizations that aim to fine-tune their decision-making mechanism and optimize their system and network, along with the competitiveness of their business. Wamba et al. (2015) noted that organizations require analytics to be used to provide information to support the decision-making process and for responding to continuously changing internal and external environments. The theoretical foundation of the relationship between BDA and firm performance is grounded in two main frameworks. Two value-added theories that depict how firms build and deploy resources are RBV and DCV.

The RBV assumes that superior resources give greater competitive advantages: the valuable, rare, and imitable resources controlled by firms. The big data analytics capabilities merge under this framework since they are strategic resources that are imitable by firms, which thus gives firms a competitive analytical advantage (Barney, 1991). BDAC includes structures, people, and management systems that organizations acquire warehouse, process, and analyze big data to improve decisions and ideas. This is especially important for firms in industries that are relatively dynamic in operations and production sector, especially the manufacturing companies, since the effective use of data in decision-making helps in the reduction of the costs of the firm to gain a competitive edge in the market (Yasmin et al., 2020). Research evidence shows that organizations that have adopted BDAC optimise their financial and non-financial performances (Akter et al., 2016).

Yet, one of the criticisms RBV received is that it is rather a static theory, which cannot consider the modern business environment as a highly dynamic environment. To counter this problem, the DCV underlines the idea that firms are required to change the configurations of their resources and capabilities as a response to the shift in market circumstances (Teece et al., 1997). As far as BDA is concerned, dynamic capabilities describe the firm's capability to combine data findings and use them promptly to address changes in the environment, such as customer preferences or disruption in the supply chain (Mikalef et al., 2020). The use and integration of data insights that facilitate endless adaptation strengthen the competitive nature of firms more dependent on their surroundings (Teece & Pisano, 1994). Considering the above, BDA is a critical element in reinforcing dynamic capabilities as it offers firms valuable insights in the form of data to enable fast decision-making that is strategic value in situations of market variability.

The conceptual framework of this study considers the interaction between BDACs, SCV, and organisational performance. It posits that BDAC has a direct impact on firm performance through two channels: efficiency and effectiveness in operations and better supply chain transparency. Analysing these dimensions, BDAC can be divided into infrastructure capabilities, human resource capabilities, and management capabilities, assisting firms in capturing the big data potential (Akter et al., 2016).

Big Data Analytics Capabilities are important for firms to enable them to capture, manage, and analyze large and disparate datasets for decision-making. Infrastructural capacity means the technological support and software for data acquisition and data warehouse (Akhtar et al., 2019). Human resources are proficiency and presence of skills by data scientists and analysts for translating the data and offering business intelligence (Ferraris et al., 2019). Management capabilities include the ability of the management to apply data management capabilities by applying leadership skills to ensure that the company adopts and embraces eBusiness technology (Brynjolfsson & McAfee, 2012). In combination, these capabilities create the basis for leveraging BDA to enhance operations and generate a competitive edge.

Supply chain visibility was found to be the mediating variable that links BDAC with firm performance. SCV is defined as the facility allowed by a firm to track and observe supply chain activities in real-time for improved control and decision-making along the value chain, as explained by Christopher and Lee (2004). Through the integration of BDA into supply chains, firms gain increased transparency that assists organisations in enhancing the efficiency of their distinct processes, reducing interruptions, and enhancing communication with other members of the chain with suppliers as well as distributors (Kache & Seuring, 2017). The enhancement of SCV has a profound positive impact on manufacturing firms since it enables them to adjust flexibly to changes in demand and supply chain risks affecting their operations.

Finally, the result of greater BDAC and SCV is an increase in organisational performance. This recurs to financial benefits, which encompass not only greater revenues but also profitability, operational efficiency, enhanced customer satisfaction, and so on. BDAC helps firms improve the efficiency and effectiveness of operations, cut costs, and spur innovation that ultimately results in high performance, especially in industries that are competitive and volatile, such as manufacturing (Akter et al., 2016). In the present research, Pakistan's manufacturing industry is being looked at as the context for BDA adoption, which is relatively new to this country. For firms in this sector, the pressure in demand for supply chain efficiency and/or globalization leads to a need for the development of BDAC to enhance SCV and remain competitive (Dubey et al., 2019).

The research model derived in this research is fully supported by the direct relationship between BDAC and organizational performance and the mediation of SCV. The foundation of this framework is provided by the Resource-Based View and the Dynamic Capabilities View, which contribute to highlighting how and in what way Pakistani manufacturing firms can build upon data resources and capabilities to achieve competitive advantage. As such, this framework resolves the research question by providing a nuanced understanding of the relationships between BDAC, SCV, and firm performance in this investigation of data-driven capabilities.

Literature Review on Big Data Analytics Capabilities (BDAC)

Big Data Analytics Capabilities are critical success factors in today's complex data-driven organizational environment. BDAC is the capacity of an organization to acquire, assess, and manage data intensity and complexity to build inductive categories that can serve as a patent for competitive decision-making and innovation. As a literature review, this paper consolidates a broad range of works done on BDAC, seeking to establish its elements, the effect it has on organizational performance and its function in the manufacturing sector.

Big data analytics capabilities are complex constructs defined across multiple resources and multiple competencies that create the capacity to harness the potential of big data. As highlighted by Akter et al. (2016), BDAC is a combinative model that embraces infrastructure, human, and management capabilities. Common infrastructure capabilities are the technological assets or systems that enable firms to aggregate or archive vast proportions of data. The human resource capabilities consist of the experience of the data scientists and analysts who understand how to interpret data about the business The management capabilities on the other hand involve the competence of the managerial personnel in the organisation in being able to utilise data for the improvement of the business.

Many authors combine numerous aspects to offer contextual analysis for the concerns of BDAC; however, three scholars have offered specific frameworks for the composition of BDAC. Yasmin et al. (2020) categorize BDAC into three key dimensions: physical, organisational and financial resources. Technical requirements refer to the system that comprises the various performance infrastructure, data management tools, and platforms. Human assets capacities discuss the skills and knowledge required to be possessed by people to make work efficient and help the organisation gain meaningful information. Management capabilities include the ability and actions of the firm's leadership to facilitate the culture for data use and integrate business strategies with data analytics.

Besides these constituents, Akhtar et al. (2019) integrate relational capabilities into BDAC, which is the experience of firms in coordinating with other individuals or organizations, such as suppliers and consumers. This relational dimension is especially significant in such manufacturing industries where end-to-end integration of suppliers, other stakeholders, and even data is mandatory. In light of this study conducted by Ferraris et al. (2019), firms are urged to have a combined approach to BDAC where technological, human, and management capital are harnessed to extract the full potential of big data.

The inability to adopt the role of BDAC in the manufacturing industry has received more attention in emerging market countries like Pakistan. Yasmin et al., 2020 have clearly explained that BDAC is quite useful for manufacturing firms who want to improve their supply chain visibility and efficiency. In the manufacturing area, BDA can track production, inventory, and shipment through the actual time and provide valuable data to enhance the accurate forecast of demand and production.

Raising the topic of BDAC and supply chain management, Dubey et al. (2019) describe the ways manufacturing firms can benefit from the application of BDAC to enhance their operational adaptability to market shifts. The integration of BDAC in supply chain management increases supply chain visibility (SCV) to enable firms to prevent disruptions. This is especially so in industries such as manufacturing, where the discontinuation of supply could incur a lot of costs and lead to a lot of wasted time. Through enhancing the SCV, more cooperation and coordination are attained among suppliers and customers, hence enhancing the SC supply chain.

Additionally, Gawankar et al. (2020) propose that BDAC can support innovation in manufacturing. With the help of big data, firms obtain information on clients' preferences concerning products or patterns in

the data that can be useful for defining new product strategies. Hence, established hypnosis that BDAC enhances firms' competitive abilities in markets where malleability and inclusiveness are key success factors.

However, some issues still arise regarding BDAC; even with numerous advantages that can be attributed to BDAC, several obstacles persist. From the available literature, Akter et al. (2016) observe that most firms face difficulty in integrating BDA within their established system owing to a dearth of talent and unproportioned support. Also, the cost involved in BDA solutions (especially the initial implementation cost) may pose a problem for many firms, especially those in weak economies such as Pakistan.

BDAC and Operational Performance

In previous studies, authors have demonstrated that BDAC has a positive change in operational performance because it addresses the problem of how to improve process optimisation, costs and efficiency. In their study, Akter et al. (2016) found that many firms that practice BDAC have later seen massive enhancements in operational procedures. Due to its ability to gather and analyze vast quantities of data, firms can track and analyze production processes and methods, minimize overheads, and enhance overall throughput. Thirdly, the information generated can help firms produce models that are most responsive to changing demand, inventory, and supply chain issues, hence improving operational flexibility.

Ferraris et al. (2019) established that complexity and dynamism in the industry, especially in manufacturing, were found to benefit from BDAC in enhancing operational performance. By analysing information collected from European firms, they found that organisations who implemented BDAC were able to manage supply chain relationships and reduce the amount of time spent on inventory management; thereby increasing productivity and reducing the overall expenses. The flexibility this gives an organization to adapt to the market in real time makes a huge contribution to its competitiveness, especially in volatile market environments.

In addition, Yasmin et al. (2020) make use of the idea that in emerging markets such as Pakistan's manufacturing sector, BDAC can increase SCV, which is significant to operational performance. SCV enables a firm to monitor the movements of materials from a particular supply chain node in real time to be able to deal with any adversity or sub-optimality that accompanies various steps in the chain. Incorporation of BDA in supply chain management is crucial to firms in facilitating coordination and mitigating vulnerabilities of supply chain disruptions, resulting in enhanced operation performance.

BDAC and Financial Performance

Apart from efficiency gains, BDAC has a positive effect on the financial performance of a firm, as the following arguments suggest. An organization with enhanced BDAC helps with strategic planning and decision-making, hence propelling the firm's revenue growth and profitability. According to Wamba et al. (2017), BDAC can assist firms in creating a better comprehend the appealing characteristics to the consumers and the trends of the market for helpful marketing, product differentiation, and product pricing. By using this information to suit the needs of the customers, firms can bring new sales and better satisfy customers, reflecting improved financial performance.

As noted in the article by Akhtar et al. (2019), BDAC helps firms minimize some of the dangers that come with new investment opportunities or new market localization strategies. For instance, the application of predictive approaches to the overall economic environment and the probable results assists firms in directing their efforts to strategies that would have been unlikely to achieve success. Such uses of BDA for forecasting and strategic decision-making give firms a tangible financial edge over rivals who do not possess such tools.

Furthermore, it is important to note that the same study conducted by Dubey et al. (2019) also expanded the understanding that BDAC is useful to firms for dealing with the risks related to finance. Companies that have the capacity to tap data and translate it into intelligence within the shortest time are in a better position to identify certain financial risks that include changes in the base currency exchange

rates, changes in the prices of commodities, and changes in demand for certain products. acting on such insights enables the firms to deal with financial strategies and defend profitability.

The literature review analyzed shows a positive link between BDAC and organizational performance to be present in the literature. BDAC, when implemented to a greater extent by firms, leads to enhanced operational performance, financial performance, and innovative capabilities. From big data, the organization is thus able to make improvements in its operations in terms of costs that need to be incurred and revenues generated, among other things. Nevertheless, there are critical issues of BDAC, including the following infrastructure, talent acquisition, and organizational culture, which are fundamental to enhancing BDAC so that firms can grab the opportunity. Since more and more firms belonging to emerging markets, like the manufacturing firms in Pakistan, have started utilizing the BDA, the evolution of sound BDAC has become imperative to sustain a unique competitive advantage in international markets.

H1: BDAC has a positive impact on organizational performance.

Supply Chain Visibility (SCV)

Supply Chain Visibility (SCV) has gained significant attention as a critical capability in enhancing supply chain efficiency and organizational performance. SCV refers to the ability of a firm to track and monitor its supply chain operations, from procurement and production to distribution, in real-time. The integration of Big Data Analytics (BDA) into supply chain processes has emerged as a key enabler of SCV, as it provides firms with the ability to access real-time data and insights on supply chain activities, leading to more informed decision-making and better overall performance. This section reviews the literature on SCV, its impact on organizational performance, and its mediating role between Big Data Analytics Capabilities (BDAC) and firm performance.

As social platforms and user engagement have increased due to big data, SCV has transitioned from simple tracking to a closer-end advanced analytical system. BDA is considered by Petersen et al. (2022) as an important enabler of SCV as it enables firms to capture and analyse big data from several nodes across the supply chain. This consists of data generated by suppliers, transportation companies, the various depots, and the shoppers. This paper has also revealed that BDA can be used to foster even higher levels of supply chain transparency, which results in better coordination, reduced inefficiencies, and better overall performance by firms.

H2: BDAC has a positive impact on supply chain visibility

SCV and Organizational Performance

A few research studies have addressed the relationship between SCV and organisational performance to determine the extent to which SCV may improve overall organisational performance. Indeed, in a cross-sectional study of firms, Baah et al. (2022) showed that SCV led to efficiency gains in operations, costs, and customer satisfaction among firms that implemented the technology. SCV is used to enhance the management of the supply chain by providing critical information within the company on stock quantities, lead time, and demand volatility. This makes it possible for firms to make informed decisions that can facilitate a smooth flow of material and finished products, and minimize cases of stock out and instances of overproduction.

Furthermore, it also generates an impact on the financial performance of cost control, and the consequences arise due to disruption of the supply chain. Dolgui and Ivanov (2022) revealed that the firms with high SCV were able to cut transportation costs, maximize warehouse space, and minimize order errors, which in turn increased the firm's profitability. SCV also improves customer satisfaction through effective customer order fulfillment, which improves the relationship between the organization and its customers.

H3: Supply chain visibility has a positive impact on organizational performance.

The Mediating Role of SCV between BDAC and Organizational Performance

Based on prior literature, SCV has emerged as an essential intermediary variable through which BDAC determines overall performance. Although BDAC provides firms with the tools to gather and manage big

data, SCV is how such added skills are applied to supply chain management for value creation. Sodhi and Tang (2019) postulated that the BDAC alone cannot assure enhanced performance unless integrated into supply chain management. SCV plays the role of an intermediary that helps firms translate BDA insights into tangible supply chain results.

SCV intervention is especially necessary in manufacturing industries that are very sensitive to supply chain dynamics. According to Bechtsis et al., (2021), a positive performance outcome is possible when a firm has high BDAC in condition of strong SCV. BDAC will assist firms in increasing transparency in all the supply chain management activities so that better adjustments can be made in production planning, inventory management, and the suppliers. This increases productivity, cuts costs, and improves the general performance of the enterprise.

Shi et al. (2023) built on the discussion of the mediating effect of SCV and found that those organizations that have developed both BDAC and SCV are much more adaptable to disruptions in the supply chain. They understand that SCV enables firms to detect risks such as supplier delays or transportation bottlenecks before these risks affect operations. This is especially so in areas like the Global supply chain since disruption can have organizational and financial implications. This, therefore, means that by adopting BDAC to enhance SCV, these risks are handled well to ensure the continuity of the firms' supply chain operations.

As McCullen et al (2015) and some SCV papers suggest, the mediating role of SCV between BDAC and performance points to the necessity for the integration of big data insights into supply chains. SCV brings improvements on a corporate level by helping a firm focus on the supply chain and increase its capacity to control and perform optimally, enhancing its operational efficiency, cost reduction, and customer satisfaction. In addition, SCV is a bridge that connects BDAC with performance to help firms turn the insights into changes to create a competitive advantage. More specifically, this study posits that BDAC and SCV integration is critical in enhancing superior performance, especially where firms face harsh supply chain realities, as is the case with firms in emerging markets.

H4: Supply chain visibility mediates the relationship between BDAC and organizational performance.

Methodology

This study uses the positivist research philosophy. The positivist method well defines the purpose of this research, which is to investigate the effect of BDAC on organizational performance. The research strategy, according to Saunders (2009), assumes that research effort adds to the body of knowledge by either generating a new theory, testing an existing theory, or developing a new theory and empirically testing it. This research uses deductive theoretical premises to describe the operational link between variables and constructs. The deductive technique is acceptable since the present study's goal is to generalize research findings based on a highly structured questionnaire from a sizable sample (Saunders, 2009).

Measurements

Scale for big data analytics capabilities for the dimensions of managerial skills and technical skills was taken from Mikalef and Krogstie, (2020). The questionnaire for supply chain visibility covered the dimensions, i.e., supply visibility, demand visibility, and market visibility, which were taken from the study of Al-Khatib (2022). Firm performance, the dependent variable of the study, was divided into two dimensions, i.e., operational performance and financial performance. Questions for operational performance were taken from the study of Al-Khatib (2022), and questions for financial performance were taken from the study of Razaghi and Shokouhyar (2021).

Population and Sampling

The population for the study in the manufacturing industry of Pakistan includes textile, automobile industry, chemical and fertilizers, etc. The sampling frame comprised of the list of companies registered with the Securities and Exchange Commission of Pakistan (SECP), Pakistan Stock Exchange (PSX), Chamber of Commerce (CoC) of Lahore, Faisalabad, Karachi, and other respective trade associations. For

this study, the random probability sampling technique has been adopted for the sample size calculated according to Saunders et al. (2016), which was 380.

Data Collection

A 7-point Likert scale was used to develop the research questionnaire. Data was collected through an online form that was created with the help of Google Forms and the link to the forms was shared with the respondents. Respondents were given free hands to respond without any interference from the researcher. The overall number of responses gathered was closed at 400. This sample size was actively considered and believed to be huge enough to give a true representation of the larger sample population within Pakistan.

Analysis

Construct Reliability and Validity

Table 1

Construct reliability and validity

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average Variance Extracted (AVE)
BDAC	0.873	0.768	0.775	0.612
OrgPer	0.871	0.909	0.903	0.586
SCV	0.756	0.869	0.826	0.563

The table provides reliability and validity statistics for three key constructs: BDAC, OrgPer, and SCV. Internal consistency and construct validity of these constructs are tested with Cronbach's Alpha, Composite Reliability (rho_a and rho_c), and Average Variance Extracted (AVE). Cronbach's Alpha points to good internal consistency for BDAC, at 0.873, and for OrgPer, at 0.871, both of which are above 0.70, which is the acceptable threshold. With a readability score of 0.756, SCV is also above the threshold, showing that there is adequate internal consistency of the items in the construct.

Composite Reliability (rho_a and rho_c) again confirms the reliability of these constructs. By considering rho_a at 0.768 and rho_c at 0.775, BDAC demonstrates good reliability, too, which means that all the items of the scale are capable of assessing the concrete construct sufficiently and adequately. The results show that OrgPer has even greater reliability as rho_a = 0.909 and rho_c = 0.903, further verifying good internal consistency. By obtaining rho_a at 0.869, as well as rho_c at 0.826, SCV affirms the sufficiency of its measurement adequacy.

The AVE values reflect the amount of commonality with variance in the construct by dint of the variance resulting from measurement error; AVEs greater than 0.50 indicate that the convergent validity is satisfactory. BDAC has an AVE of 0.612, which implies that the BDAC items quantified 61.2 % of the total variance of the construct. OrgPer with an AVE of 0.586 and SCV with an AVE of 0.563 is higher than the benchmark of 0.50, thus confirming agreeing on convergent validity. The results of the table prove that BDAC, OrgPer, and SCV all possess satisfactory levels of reliability and validity. The reliability coefficient is high for BDAC and OrgPer and rather high for SCV.

Heterotrait-monotrait ratio (HTMT)

Table 2

HTMT analysis

	Heterotrait-monotrait Ratio (HTMT)
OrgPer <-> BDAC	0.694
SCV <-> BDAC	0.787
SCV <-> OrgPer	0.853

Table 3 displays the estimate of the Heterotrait-Monotrait Ratio (HTMT) to evaluate the discriminant validity between the constructs in this research. Discriminant validity confirms that the measures that are constructed are outside the measurement space of other variables. According to the HTMT value between

OrgPer and BDAC, the score we get is 0.694, which is below the cut-off of 0.85. This means that these two constructs are sufficiently separate from one another in terms of the data analyzed in the study. The HTMT value between SCV and BDAC is 788, once again below 85, which means that SCV and BDAC are also different constructs. Last, the HTMT between SCV and OrgPer is 0.853, which is normative but slightly above 0.85 which is ideal most of the time in a series of tests. This means that even though SCV and OrgPer correlate, they still possess the discriminant validity measure. The HTMT values obtained indicate that BDAC, OrgPer, and SCV are sufficiently heterogeneous to allow for accurate discriminant validity and provide evidence for the discriminant validity of the model.

Fornell-Larcker Criterion

Table 3

Fornell-larcker analysis

	BDAC	OrgPer	SCV
BDAC	0.642		
OrgPer	0.583	0.765	
SCV	0.642	0.901	0.695

Discriminant validity, according to the Fornell-Larcker criterion, involves the comparison of the square root of the AVE of each construct with the inter-construct correlation. For BDAC, AVE is squarely rooted to result in 0.642, while values obtained for OrgPer and SCV are 0.583 and 0.642, respectively, and this affirms good discriminant validity. OrgPer, with a squared root of AVE of 0.765, poses a sufficient discriminant validity with BDAC of .583 but shares high commonality with SCV .901. Likewise, SCV has the square root of AVE of 0.695, higher than 642 with BDAC but not with OrgPer.9001, indicating that SCV and OrgPer are related.

Collinearity Statistics (VIF)

Table 4

VIF

Constructs	VIF
BDAC1	1.126
BDACQ2	1.762
BDACQ3	1.641
BDACQ4	1.698
BDACQ5	1.056
BDACQ6	1.296
OrgPerQ1	1.493
OrgPerQ2	1.094
OrgPerQ3	2.710
OrgPerQ4	1.061
OrgPerQ5	1.892
OrgPerQ6	1.340
OrgPerQ7	1.198
SCVQ1	1.263
SCVQ2	2.180
SCVQ3	1.863
SCVQ4	1.101
SCVQ5	2.243
SCVQ6	2.034

The collinearity statistics given above involve the use of the VIF for the BDAC, OrgPer, and SCV indicators. VIF measures the amount of multicollinearity between the predictor variables; the benchmark is 5.0, and therefore, every VIF value below this marks no evidence of multicollinearity. For BDAC, all VIF values are less than cut-off values 1.056 to 1.762, which means there is no problem of multicollinearity in BDAC indicators. VIF values for OrgPer range from 1.061 to 2.710 with a maximum value of OrgPerQ3, implying that there is no multicollinearity problem at all, though close to the acceptable limit. In the case of SCV as well, the VIF values obtained are between SCV 1.101 and 2.243, which also makes it clear that there is no high multi-collinearity amongst the SCV indicators. Multicollinearity between different model predictors is not problematic in the current model since all VIF values of BDAC, OrgPer, and SCV are under 3.

Quality Analysis

Table 5

R-Square

	R-square	R-Square Adjusted
OrgPer	0.811	0.810
SCV	0.413	0.411

The first two values in the table above show the R-square and R-square adjusted values by a factor of Organizational Performance (OrgPer) and Supply Chain Visibility (SCV). R – square is the measure of the variation between groups about the total variation evident in the research and it depicts the proportion of the total variance in the dependent variable caused by the independent variable while the adjusted R – square is the adjusted R – square that does not factor the number of prediction variables used leading to increased accuracy when more than one variety is used in the compromise.

For OrgPer, the R-square value is 0.811, indicating that 81.1% of the changes in Organizational Performance are accounted for by the predictors. The adjusted squared multiple correlation coefficient is 0.810, and this is highly similar to the calculated squared multiple correlation coefficient; this shows that the model has no high redundancy but has a good fit given the number of predictors used. For SCV, the obtained R-square is 0.413, which reveals that 41.3 percent of the variability in Supply Chain Visibility is attributable to the underlying predictors. The adjusted R-square is 0.411, which is close to the R-square value, so it could be realized that the model is consistent. The R-square and adjusted R-square values relate to the strength of the present model in relation to the variance of OrgPer and SCV, with the R-squares for OrgPer approaching 0.6720, showing a strong percentage of the variance explained.

Path Coefficients

Figure 1

Model

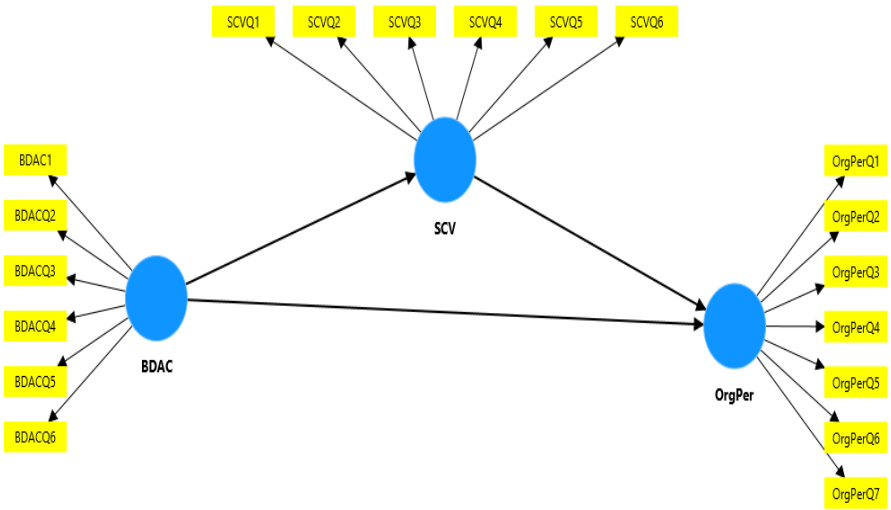

Figure 2

Path coefficients

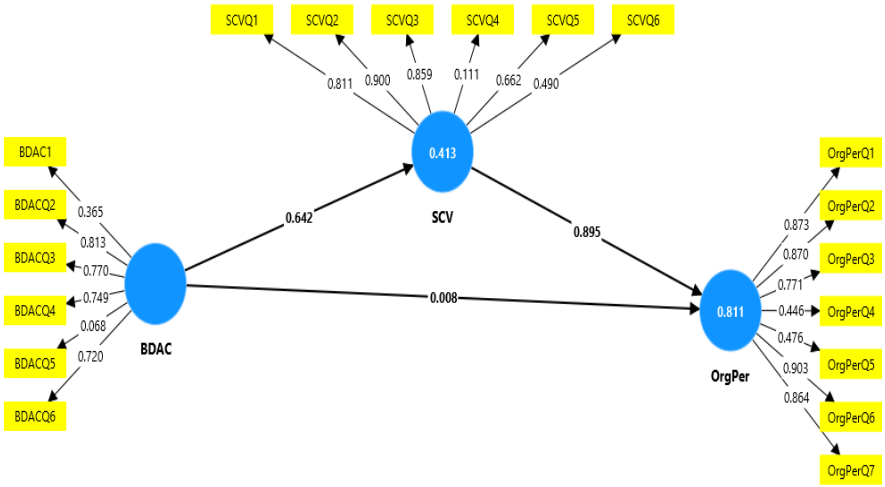

Table 6

Path coefficients

	Path Coefficients
BDAC -> OrgPer	0.008
BDAC -> SCV	0.642
SCV -> OrgPer	0.895

The results of the model include path coefficients that indicate the strength and the direction of the connections within the proposed model. These coefficients show how one variable affects another of interest since larger coefficients imply a high level of association.

By looking at the exact coefficient values presented in the following equation, we can see that BDAC has the exact coefficient of 0.008, which indicates that BDAC has a low direct effect on OrgPer. However, the path coefficient estimate from BDAC to SCV is 0.642, signifying a positive large and significant association of BDAC with Supply Chain Visibility. This implies that the integration of BDAC leads to a considerable improvement of SCV. Finally, the total effect estimate for SCV to OrgPer is 0.895, proving the hypothesis that SCV has a very strong positive effect on Organizational Performance. This means that SCV is a primary driver of enhanced organizational performance.

Mediation Analysis

Table 7

Mediation analysis

	Specific Indirect Effects
BDAC -> SCV -> OrgPer	0.575

Table 8 shows the essential part of the mediation analysis, namely, the direct effect of BDAC on OrgPer through SCV. The Badged direct effect, as estimated by the current analysis, reveals the total strength of the BDAC-SCV- OrgPer relationship, indicating the indirect way by which BDAC affects Organizational Performance. At the same time, the quantitative measure of the indirect impact of BDAC on OrgPer through SCV is equal to 0.575. As seen above, this has a large value, suggesting that most of BDAC's impact on Organizational Performance is indirect and is realized mostly through Supply Chain Visibility. Taking into account that the immediate impact of BDAC on OrgPer is weak and equals 0.008, this result speaks volumes of the exceptional mediating potential of SCV. In other words, BDAC improves or increases SCV, a factor that will tremendously influence Organizational Performance. These findings provide evidence for the robustness of the mediation effect in which SCV is the major way through which BDAC enhances

organizational performance. Thus, the organisations that have well-constructed BDAC successfully realize the increase in organisational performance mainly by the increase in the supply chain visibility.

Table 8

Total effects

	Total Effects
BDAC -> OrgPer	0.583
BDAC -> SCV	0.642
SCV -> OrgPer	0.895

Total effects are shown in Table 9, which includes direct and total effects as the combined influence of one variable on another. These values give a clue on how the constructs are related as per the model. The total impact of BDAC on OrgPer equals 0.583. This value is higher than the direct effect, which is equal to 0.008, and suggests that a vast majority of the variances in organizational performance attributed to BDAC go through the pathway represented by supply chain visibility (SCV). The total effect of BDAC on SCV is still positive, with a value of 0.642, which means that BDAC has a direct positive effect on SCV. When we sum up all the direct effects, we get the total effect of SCV on OrgPer as 0.895, thus strongly corroborating the direct relationship of SCV with organizational performance. This underlines the mediating role of SCV. Thus, although total BDAC changes OrgPer with little direct influence, the cumulative impression demonstrates a considerable combined impact, mainly through SCV. This means that SCV is an important determinant of Organizational Performance in BDAC.

Discussion

The present study of BDAC, SCV, and OrgPer has provided critical insights into the research findings, which are discussed as follows. First, BDAC positively and significantly affects SCV, as revealed by the path coefficient of 0.642. This implies that organizations with advanced BDAC can improve the supply chain visibility and, as a result, manage the operations of the supply chain in real time. Nevertheless, the total effect of BDAC on OrgPer is low (0.008), meaning that BDAC alone is not responsible for improving organizational performance. Consequently, it was revealed that the indirect path from BDAC to OrgPer via SCV is thus found to be a significant mediating path with a specific indirect effect equal to 0.575. Interestingly, this underscores SCV as the key avenue through which BDAC drives up organizational performance. In addition, OrgPer has a higher direct effect with SCV, with a path coefficient of 0.895, which suggests that enhancing SCV can significantly enhance the degree of organizational performance.

These findings are supported by the R-squared values, where SCV accounts for 41.3% of its total variance through BDAC, and OrgPer explains 81.1% of its total variance, primarily because of SCV. The direct and total effects suggest the importance of SCV as the main mediator through which the BDAC impacts OrgPer, the BDAC whereas, has no direct influence on performance, but has a total effect with a value of 0.583 for OrgPer. Combined, these findings imply that accountability-focused BDAC can benefit organizations that want to enhance performance by developing the supply chain visibility of these capabilities. There exists an indirect relationship between BDAC and OrgPer where SCV plays a middleman in supporting the fact that effective supply chain management is a key enabler of an organization's success.

The present results are also consistent with the prior research that posts that BDAC affects organizational results via multiple modes other than the direct method and also affects the supply chain factors mainly. Li et al. (2021) argued that BDAC increases firms' opportunity to monitor the real-time status of the supply chain, support effective decisions, and decrease risks, sharing with this current research that SCV also acts as a mediator between BDAC and OrgPer. This study also showed that DBAC has an even stronger indirect impact on performance when operational visibility mediates the relationship, further underlining the importance of SCV in converting asset-enhanced BDAC into better performance outcomes.

In the same vein, Yang et al. (2022) showed the moderating activity of SCV in connecting advanced data analytics with more effective and flexible supply chain coordination and performance. This view

coincides with a conclusion in the present study that SCV is the only channel through which BDAC influences OrgPer since they argued that the use of data analytics in supply chain management is the primary driver of performance improvement. They supply more evidence from the high path coefficient of BDAC to SCV (0.642) and SCV to OrgPer (0.895) for their assertion that business visibility, through data capabilities, is critical to generating analytics benefits and ROI.

Zhang and Zhang (2020) also found that SCV positively influences BDAC and impacts organizational performance. Farooq et al. also posited that supply chain visibility enhances the firm's ability to manage supply chain disruptions and resource allocation, enhancing organizational performance. This agrees with the current study's indirect effect of BDAC on OrgPer via SCV of 0.575, meaning that SCV is a central mediator. The two papers highlight supply chain visibility as the channel by which BDAC receives manifestation in terms of performance enablers.

Therefore, the current findings add to and support the conclusions made by Li et al. (2021), Yang et al. (2022), and Zhang & Zhang (2020), who all stressed the moderating role of SCV capturing the effect of BDAC on performance. These studies prove time and again that the actual worth of BDAC is realized in its impact on SCV and the tremendous changes that such a relationship brings to the improvement of organizational results. However, as will be discussed later in this paper, to fully reap the benefits of BDAC, firms need to enhance their supply chain visibility.

Implications of the Study

This research has several meaningful applications for organizations, especially those operating in the manufacturing space. First, it suggests increasing Supply Chain Visibility, with Big Data Analytics Capabilities as the central argument for doing so. There is evidence that supply chain-oriented data analytics practices can generate highly valuable real-time information about supply chain processes and activities which improve organizational performance by minimizing inefficiencies and waste. Furthermore, manufacturing firms should aim not only to obtain powerful data analytic tools but also to ensure that their human and management capital are ready to harness the potential of these powerful tools. Moreover, it establishes the centrality of visibility for businesses, which this study has distinguished across the supply chains. In essence, by enhancing the transparency and coordination of activities within the supply chain, operational capacity may be enhanced to handle disruption and other occurrences within the supply chain that give companies an edge in the markets.

Limitations and Future Recommendations

The present research has some methodological limitations that should be mentioned. First, it targets a particular industry and geographic area, which means that the results cannot be generalized. Subsequent research should be conducted across different industries, geographic regions and sector types i.e. services to validate the findings for generalization of the results and findings. In the same way, the study relied on cross-sectional data, meaning that the causal relationships in instances were limited to cross-sectional facial comparisons rather than an evaluation of temporal changes. In future work, the following limitation could be overcome by using longitudinal methods to analyze the effects of BDAC and SCV on performance in the long run. The future researchers should consider using qualitative research for the efficacy of the findings.

The following are possible directions for future research. The moderating relationship should be researched with the introduction of moderating variables like environmental dynamism, top management support, firm size etc. which might yield a richer understanding of the strength of the BDAC-SCV-performance relationship under different conditions. Moreover, future research could apply other mediating variables, such as supply chain flexibility or operational agility, to unravel other mediating roles of BDAC regarding organizational performance. These variables could uncover other factors that could open up new channels through which the impact of BDAC on firm performance is achieved, hence providing a rich understanding of how data capabilities can be leveraged to provide operational and strategic advantages to the firms.

Conclusions

The findings of this research provide valuable information for understanding the correlation between Big Data Analytics Capabilities, Supply Chain Visibility, and Organizational Performance in the selected manufacturing firms of Pakistan. The results prove that Big Data Analytics Capabilities have no apparent direct effect on organizations' performance; however, they act as an important enabler for supply chain visibility, performing as an important mediator of the relationship between the variables under consideration. Supply chain visibility appears to be an important mediator influencing firms' increased performance in leveraging their data capabilities.

The findings underline the need to align Big Data Analytics Capabilities within the supply chain which helps to enhance the visibility aspect. Those organizations that spend time and resources in creating both managerial and analytical capability alongside supply chain visibility while leveraging big data analytics are more likely to be very responsive to market forces and effectively monitor risks. The study also reveals that to use big data analytics to their full potential, firms need to place considerable supply chain visibility across their supply chains.

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