THE ROLE OF BIG DATA ANALYTICS STRATEGY IN ENHANCING FIRM PERFORMANCE: A PROCESS-DRIVEN APPROACH THROUGH SUPPLY CHAIN EFFICIENCY

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Abstract

This study examines how big data analytics (BDA) enhances supply chain performance by analyzing two key process pathways: decision-making and forecasting. Using data collected from 400 supply chain managers across various industries, the study applies structural equation modelling (SEM) using SmartPLS to test the relationships among BDA capabilities, supply chain efficiency (SCE), and firm-level performance outcomes. The results show that while BDA improves both forecasting and decision-making processes (DMP), only decision-making consistently drives higher SCE. Forecasting, though technically enhanced by BDA, fails to translate into efficiency gains due to volatility and uncertainty inherent in supply chain environments. SCE is found to fully mediate the relationship between BDA-enabled decision-making and operational and financial performance. This study extends and contributes to Chatterjee et al. (2023) by highlighting process-specific mechanisms in BDA adoption. The findings suggest that organizations should adopt a decision-centric BDA strategy, emphasizing real-time, data-driven choices over predictive modelling alone. This study contributes theoretically by highlighting process-specific mechanisms and offers practical guidance for optimizing BDA investments.

Keywords: Big Data Analytics, Process Driven Approach, Supply Chain Efficiency, Decision-Making, Forecasting, Firm Performance, SEM, Operational Performance

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1. INTRODUCTION

In the current era of digital transformation, firms are under intense pressure to respond to market volatility, rising customer expectations, and operational disruptions. The current competitive environment demands faster, more accurate decision-making and predictive capabilities (Neiroukh et al., 2024; Rieg & Ulrich, 2024). Consequently, data has emerged as one of the most strategic assets available to firms (Hannila et al., 2022), capable of transforming business models and competitive strategies. Organisations across sectors are aggressively investing in big data analytics (BDA) tools to gain real-time insights, anticipate demand, optimise resources, and mitigate operational risks (Namasivayam et al., 2025; Nguyen et al., 2025; Rosnidah et al., 2022). However, despite substantial investment, the measurable impact of BDA on overall firm performance (OFP) remains inconsistent and often unclear. Managers perceive BDA as a technological resource rather than as an enabler of strategic and operational processes. The existing literature perceives BDA as a transformative capability that allows firms to manage, process, and analyse large volumes of structured and unstructured data (Gunasekaran et al., 2017; Fosso Wamba et al., 2020). Most studies take a technology-centric or outcome-focused view, often overlooking the internal mechanisms, especially business processes, through which BDA delivers value. Hence, there is a clear lack of perspective that BDA should be looked at. Specifically, considering how many industries utilize BDA in enhancing decision-making processes (DMP) and forecasting capabilities (FCP), a study that integrates all together in a systematic process remains underexplored. This process-oriented gap in the literature suggests that a study that sheds light on BDA as a factor that ensures the desired outcome through the enhancement of intermediate capabilities is needed. Yet, few empirical studies have tested these mediation effects rigorously, leaving a critical void in both academic understanding and managerial practice. This study focuses on the supply chain management domain, where the adoption of BDA is examined not as a standalone driver of performance but as a strategic enabler of critical intermediary processes. Specifically, the research investigates whether BDA enhances the decision-making process and FCP within firms. This study will test whether under BDA-driven decision-making and forecasting process path leads to greater supply chain efficiency (SCE), which subsequently translates into enhanced financial and operational performance. It will be tested whether by adopting a two-way process-driven perspective, BDA contributes to firm-level outcomes, offering a more nuanced understanding beyond direct input-output relationships. Similarly, it will be tested whether BDA-based DMP and forecasting process both contribute equally to the performance of the supply chain. The questions this study will be answering are as follows:

RQ1: How does BDA improve decision-making processes and forecasting capabilities within firms?

RQ2: Does supply chain efficiency mediate the relationship between BDA-driven processes and firm performance?

RQ3: Do decision-making and forecasting processes contribute equally to supply chain efficiency and subsequent firm performance?

The aim of this study is to examine how BDA enhances firm performance through process-driven pathways of decision-making, forecasting, and SCE. A process-driven model that links BDA adoption to firm performance through a series of interrelated mechanisms will be proposed through a rigorous review of the literature. To validate this model, the study employs the partial least squares structural equation modelling (PLS-SEM) approach, analysing responses from 400 firm-level managers familiar with data analytics practices. The findings aim to contribute to both theory and practice by shifting the focus from technological adoption to the internal process pathways that generate value. This approach not only enriches the academic discourse on BDA but also offers actionable insights for business leaders seeking to align their analytics investments with tangible performance improvements. Ultimately, this research underscores the importance of viewing BDA not as a standalone solution but as a catalyst that enhances core business processes essential to sustainable firm performance. This research contribution extends the discussion's focus from a technology-centric to a process-driven perspective for BDA, emphasising SCE as an influential mediator between BDA processes and firm performance. The significance of this study lies in demonstrating how a process-driven use of BDA can transform SCE into a strategic lever for enhancing firm performance. It provides rigorous procedural guidance (PLS-SEM) analysis on a large sample, and gives an idea to managers and their decision-making of the issues about how to apply decision-based BDA and gain stronger operational and financial results.

This paper is organized in the following way. Section 2 is the literature review, including the adoption of BDA, business processes, SCE, firm performance, and explanatory function of process and performance, and ends with a concept map and recognition of the literature gap. Section 3 describes research design and methods of data collection. In Section 4, the empirical results are given, and in Section 5, the results are discussed in terms of theoretical and managerial implications. Lastly, Section 6 wraps up the paper with a conclusion on the contribution the paper made, limitations, and future research directions.

2. LITERATURE REVIEW

2.1. Hypotheses development

The transformative role of BDA in enhancing business processes is significant. Chatterjee et al. (2023) mentioned the business process as the DMP and the forecasting process. BDA enables firms to extract actionable insights from vast datasets, improving the accuracy and speed of strategic decisions (Adewusi et al., 2024). Big data analysis also strengthens forecasting accuracy (Devaraj et al., 2021). These process improvements are especially vital within supply chain management, where timely and precise decisions directly affect efficiency. Supply chains have their requirements for accurate decision-making and forecasting. Effective supply

chains rely heavily on precise demand predictions (Muthukalyani, 2023) and agile decision-making (Oliveira-Dias et al., 2022) to optimize inventory, reduce waste, and enhance overall operational responsiveness. Previous studies support BDA as a driver of decision-making and forecasting in various other industry domains. Similarly, supply chains also depend heavily on decision-making and forecasting. Considering this, the following hypotheses can be proposed:

H1a: BDA adoption positively influences the decision-making process.

H1b: Adopting BDA positively influences forecasting.

Supply chain output is measured through its efficiency areas, and past studies have stated that the DMP and forecasting are needed to increase such efficiency (Tadayonrad & Ndiaye, 2023). SCE is a sub-domain of business efficiency. Business efficiency in many sectors has associated itself with the DMP and forecasting. For instance, BDA-enabled decision-making has led to faster clinical responses, safety, and optimized resource allocation in healthcare domains (Mazumder, 2024). Response, safety, and resource allocation are areas where efficiency depends, hence suggesting their positive effect on efficiency. In manufacturing, real-time forecasting models powered by analytics have reduced lead times and improved production planning (Al Bashar et al., 2024). Supply chains are not so different than these sectors. Past studies have also said that SCE has improved through informed decision-making. Jampani et al. (2023) mentioned that forecasting allows for supply chain optimization. This indicates that if BDA-based decision-making or forecasting is allowed, it should also improve the supply chain's process optimisation and efficiency building. Given the complexity and dynamic nature of supply chains, they arguably stand to benefit even more from improvements in these core processes. Considering this, the following hypotheses can be proposed:

H2a: The decision-making process positively influences supply chain efficiency.

H2b: The forecasting process positively influences supply chain efficiency.

Efficiency is not just an output that the supply chain relies on; it is the driver of performance as well (Richey et al., 2022). It is a strategic performance driver that underpins a firm's ability to generate financial and operational gains. Financial performance reflects a firm's ability to convert resources into revenue and profit, while operational performance focuses on process excellence, speed, flexibility, and quality. Efficient supply means reducing process redundancies, minimizing waste, and facilitating agility. (Abdelilah et al., 2023; Al Doghan & Sundram, 2023). These are all firm performance metrics driving both profitability and service excellence. In the operational domain, SCE needs to be enhanced through throughput, delivery speed, and service quality (Siagian et al., 2021). In financial terms, efficiency translates into lower operational costs, reduced capital tied up in inventory, and improved cash flow. Therefore, past studies have suggested that efficiency leads to performance outcomes. Considering this, if BDA-based decision making and forecasting allow efficiency improvement, then it should also lead to financial and operational performance as well.

H3a: Supply chain efficiency positively influences financial performance.

H3b: Supply chain efficiency positively influences operational performance.

Efficacy when contributing to financial and operational performance also leads to overall performance and competitive positioning of the firm (Alojail & Khan, 2023). Past studies have mentioned that firms with stronger operational capabilities demonstrated higher overall performance when in volatile markets (Handoyo et al., 2023). Having higher operational performance means a firm can put all its resources together, which leads to higher firm performance. However, these studies are not exclusively towards supply chain domains. Still, considering supply chains are core enablers of both cost optimization and service reliability, it is expected that any improvements in operational or financial outcomes stemming from SCE should directly contribute to enhancing firm performance. Similarly, increased profitability and cash flow, hallmarks of strong financial performance, directly impact strategic investment capabilities and long-term survival. BDA enabled higher efficiency, leading to higher operational and financial performance should lead to higher firm performance. The following hypotheses can be proposed:

H4a: Financial performance positively influences overall firm performance.

H4b: Operational performance positively influences overall firm performance.

The process through which BDA will increase firm performance is associated with intermediary correlation. This study wants to test this intermediary correlation through which firm performance is influenced. Past studies have indicated that streamlined operations are possible when decisions are made using real-time data (Olayinka, 2021), allowing firms to minimize uncertainty and proactively manage disruptions. Improved coordination among supply chain nodes, guaranteed accurate demand planning, and less operational redundancy follow from better decision-making is which can be gained via having better decision-making. Hence, BDA can improve the decision-making ability of firm managers and, in return, they increase the firm's efficiency by being more responsive and agile in supply chain management. Hence following hypothesis can be proposed:

H5a: The decision-making process serves as an intermediary through which BDA adoption enhances supply chain efficiency.

As previously discussed, BDA and forecasting are part of supply chain operations; improvement in efficiency can be attributed more to the intermediatory power of forecasting. Forecasting acting as an intermediary that affects efficiency by making the operational process agile, is proven by many past studies. In this context, forecasting is not merely a feature of BDA; it operationalizes it. Anitha and Patil (2018) mentioned that forecasting bridges the gap between data and operational execution.

This means that firms analyzing their big data will lead to operational efficiency improvement as managers do better and accurate forecasting based on the data insights. This is an intermediary power. Hence, supply chains' efficiency gains observed from BDA adoption in supply chains can be mostly attributed to the forecasting ability managers possess. The following hypothesis can be proposed:

H5b: The forecasting process serves as an intermediary through which BDA adoption enhances supply chain efficiency.

An improvement in decision-making is the reason why efficiency gets improved under a BDA-enabled firm environment. Past studies have indicated that streamlined operation is possible when effective decision-making, especially when powered by BDA, enhances responsiveness and alignment in supply chain operations (Giannakis & Louis, 2016). However, improved decisions alone do not guarantee superior firm performance unless they translate into operational efficiency. Studies show that strategic decisions increase performance only when embedded in efficient supply chain process management. Therefore, SCE acts as a critical bridge between decision quality and performance outcomes. The following hypothesis can be proposed:

H6a: Supply chain efficiency mediates the relationship between the decision-making process and financial performance.

Forecasting accuracy is essential for demand planning, inventory control, and procurement (Tadayonrad & Ndiaye, 2023). While BDA enables high-accuracy forecasting, its performance impact depends on how well forecasts are used to streamline supply chain processes. Forecasting is realized only when supply operations become more responsive and leaner. This translates into higher efficiency. Past studies have shown that efficiency in the supply chain contributes to firm performance (Siagian et al., 2021). Thus, SCE is a mechanism through which forecasting affects firm performance. The following hypothesis can be proposed:

H6b: Supply chain efficiency mediates the relationship between the forecasting process and financial performance.

Financial performance can be described as a key channel through which operational enhancements can be coupled with firm-level performance. Increased efficiency in the supply chain leads directly to increased profitability and financial stability when it improves cost reduction, inventory control and capital utilization. Effective supply chains reduce wastage, enhance cash flow, and help a firm to reinforce its fiscal base, which combine to achieve long time competitiveness and strategic development. Hence, it is theorized that:

H6c: Supply chain efficiency mediates the relationship between the decision-making process and operational performance.

Operational performance is the actual implementation of efficiency in the supply chain, which includes delivery reliability, process flexibility, throughput, and service quality. These are operational dimensions improved by better supply chain efficiency that allows firms to react quicker to market changes and customer demands. This is how operational gains eventually result in high-quality firm performance in terms of agility, responsiveness, and productivity. It is then suggested that:

H6d: Supply chain efficiency mediates the relationship between the forecasting process and operational performance.

Efficiency in supply chains directly contributes to cost savings, inventory turnover, and capital efficiency, all essential financial metrics (He et al., 2024). However, supply chain improvements alone do not equate to competitive advantage unless they impact bottom-line performance. It is expected that financial performance translates operational efficiency into tangible firm-level benefits. At the same time, financial strength also helps companies to invest in technology, maintain a competitive edge, and better resist market instability. Therefore, financial performance gained via having higher efficiency will lead to higher firm performance, thus establishing itself as a mediator. Considering this, the following hypothesis will be proposed:

H7a: Financial performance mediates the relationship between supply chain efficiency and overall firm performance.

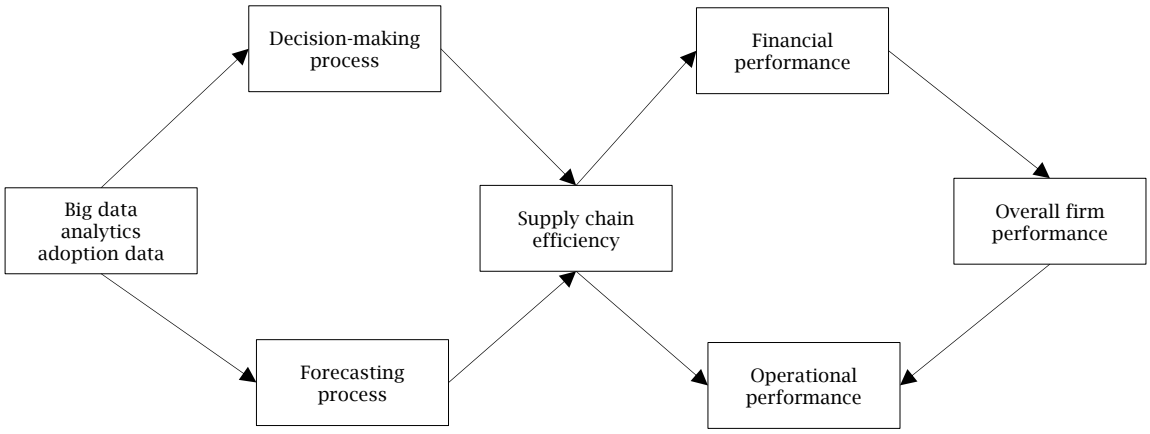
SCE, which entails the streamlined flow of goods, reduced cycle times, and enhanced responsiveness, is often the first operational benefit realized from data-driven and process-optimized strategies. However, it is through improved operational performance, measured in terms of throughput, delivery accuracy, inventory turnover, and service level, that these efficiency gains become tangible performance outcomes at the firm level. Some studies have argued that SCE sets the foundation and operational performance that ultimately impacts customer satisfaction, agility, and scalability, especially in turbulent environments. Operational excellence acts as the execution mechanism through which firms realize gains from process efficiency. Popovič et al. (2018) highlight that firms with high operational performance demonstrate better adaptability and responsiveness, which are crucial for maintaining competitive advantage.

H7b: Operational performance mediates the relationship between supply chain efficiency and overall firm performance.

2.2. Conceptual map

Considering the literature review relationship between BDA and performance goes through a process. The process is being presented in Figure 1 below, which underscores how BDA adoption enhances OFP through distinct pathways. It proposes two key processes — decision-making and forecasting, as mediators linking BDA to SCE, which in turn drives financial and operational performance, ultimately influencing OFP.

Figure 1. Conceptual map



2.3. Literature gap

The current literature on BDA identifies three notable gaps that this study seeks to solve. Although many studies focus on the technological implementation of BDA, there is a lack of studies into the process-oriented mechanisms by which BDA boosts DMP and FCP to improve SCE. Secondly, despite China's crucial position in global supply chains, academic focus on the adoption of BDA inside China's supply chain environment is notably scarce, resulting in a geographical research deficiency. Third, while BDA applications have been thoroughly examined in fields such as finance and healthcare, empirical research particularly targeting supply chain management remains disproportionately limited concerning its economic significance. The interrelated gaps conceptual (process mechanisms), contextual (China focus), and sectoral (supply chain emphasis) constitute significant deficiencies in the current comprehension of BDA facilitates operational enhancements in global supply networks, especially within emerging market environments where digital transformation trajectories may diverge markedly from conventional Western paradigms.

3. METHODOLOGY

This study employs a quantitative, cross-sectional research design to examine the impact of BDA on supply chain decision-making, forecasting, and firm performance. Primary data have been collected through a structured survey administered to 400 retail supply chain managers in China, selected via purposive sampling to ensure respondents possess relevant expertise in BDA adoption and supply chain operations. The survey questionnaire has been adapted from Chatterjee et al. (2023) (refer to Appendix), ensuring validated measurement scales for constructs such as *BDA* adoption, *DMP*, *FCP*, supply chain efficiency (*SCE*), financial performance (*FIN*), operational performance (*OPE*), and overall firm performance (*OFP*). The instrument will use a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) to capture perceptual responses. Data analysis has been conducted using SmartPLS 4.0, a PLS-SEM tool suitable for predictive and exploratory research. PLS-SEM is ideal for assessing complex mediation models and handling non-normal data distributions. Alternative approaches, including covariance-based (CB)-SEM, hierarchical linear modelling, or longitudinal and mixed-method methods, were taken into account. CB-SEM, however, requires strong normality, hierarchical linear modeling necessitates nested data, and longitudinal or mixed methods are cumbersome. The reason why PLS-SEM was preferred is that it works effectively with complex mediation models, non-normal data, and exploratory analysis as compared to alternative methods. The survey data obtained were first filtered on completeness, normality, and outliers. The evaluation of measurement models evaluated reliability (Cronbach's alpha, rhoA, rhoC) and convergent validity (outer loadings, average variance extracted, AVE) to confirm the consistency of construct measurement. Discriminant validity was also tested. PLS-SEM was then used to test the structural model to evaluate path coefficients, R^2, and effect sizes. Mediation testing was tested with bootstrapping (5,000 resamples). This methodological procedure permitted strong testing of connections among BDA, decision-making, forecasting, efficiency, and performance of the firm.

4. FINDINGS

This sample (N = 400) effectively represents China's retail supply chain sector. Males dominate (64.5%), reflecting industry trends, while females comprise 35%. Most respondents are mid-career professionals aged 30–49 (69.8%), with adequate representation across experience levels (< 3 years: 25%; > 10 years: 29.5%). Supply chain managers form the largest group (42%), followed by operations (22.5%) and IT/Data roles (20.5%). Company sizes are well-distributed: small and medium enterprises (52.5%) and large corporations (47.5%). While senior professionals (50 +: 8.5%) are underrepresented, the sample captures key decision-makers (40–49: 35.2%) and technical roles crucial for BDA insights, ensuring balanced perspectives across organizational levels and firm sizes.

Table 1. Demographic statistics

Variable	*Category*	*Frequency*	*Percentage*
Gender	Male	258	64.5%
	Female	140	35.0%
	Other	2	0.5%
Age group	Under 30 years old	87	21.8%
	30–39 years old	138	34.5%
	40–49 years old	141	35.2%
	50 + years old	34	8.5%
Job position	Supply chain manager	168	42.0%
	Operations manager	90	22.5%
	IT/Data analytics manager	82	20.5%
	Logistics manager	60	15.0%
Experience	< 3 years	100	25.0%
	3–5 years	100	25.0%
	6–10 years	82	20.5%
	> 10 years	118	29.5%
Company size	Small (1–50)	80	20.0%
	Medium (51–500)	130	32.5%
	Large (501–5,000)	90	22.5%
	Very large (> 5,000)	100	25.0%

BDA shows excellent reliability with Cronbach's alpha (0.961), rhoA (0.964), and rhoC (0.972), all exceeding 0.9, along with a high AVE (0.895) (Haji-Othman & Yusuff, 2022; Cheung et al., 2024). This indicates exceptionally consistent measurement of BDA adoption, suggesting the scale items strongly converge on this construct. *DMP* demonstrates strong reliability (alpha = 0.909, rhoA = 0.915, rhoC = 0.934) with acceptable AVE (0.743), confirming the decision-making process is measured reliably, though the AVE suggests slightly more variance in items. *SCE* has the weakest metrics (alpha = 0.682, below the 0.7 threshold; AVE = 0.605), indicating potential issues in *SCE* measurement. However, its rhoA (0.879) and rhoC (0.821) suggest acceptable composite reliability, possibly due to fewer but more varied items. *FCP* excels (alpha = 0.946, rhoA = 0.947, rhoC = 0.959, AVE = 0.823), confirming the forecasting process scale is highly consistent. *FIN* (alpha = 0.918, rhoA = 0.918, rhoC = 0.942, AVE = 0.803) and *OPE* (alpha = 0.883, rhoA = 0.884, rhoC = 0.919, AVE = 0.740) both show strong reliability for performance measures. *OFP* (alpha = 0.868, rhoA = 0.874, rhoC = 0.919, AVE = 0.792) also meets all thresholds, though its slightly lower alpha suggests minor item heterogeneity.

Table 2. Reliability

Variable	*Cronbach's alpha*	*Composite reliability (rhoA)*	*Composite reliability (rhoC)*	*Average variance extracted (AVE)*
BDA	0.961	0.964	0.972	0.895
DMP	0.909	0.915	0.934	0.743
SCE	0.682	0.879	0.821	0.605
FCP	0.946	0.947	0.959	0.823
FIN	0.918	0.918	0.942	0.803
OFP	0.868	0.874	0.919	0.792
OPE	0.883	0.884	0.919	0.740

The outer loadings analysis in Table 3 below confirms strong indicator reliability for most constructs, with loadings exceeding the 0.70 threshold (Ab Hamid et al., 2017). *BDA* (0.906–0.977), *FCP* (0.882–0.920), *FIN* (0.873–0.916), *OFP* (0.874–0.920), and *OPE* (0.845–0.877) demonstrate excellent convergent validity.

Table 3. Outer loadings

Variable	BDA	DMP	SCE	FCP	FIN	OFP	OPE
BDA1	0.977						
BDA2	0.941						
BDA3	0.906						
BDA4	0.959						
DMP1		0.669					
DMP2		0.955					
DMP3		0.877					
DMP4		0.875					
DMP5		0.906					
SCE1			0.881				
SCE2			0.902				
SCE3			0.910				
SCE4			-0.001				
FCP1				0.915			
FCP2				0.882			
FCP3				0.915			
FCP4				0.904			
FCP5				0.920			
FIN1					0.916		
FIN2					0.888		
FIN3					0.873		
FIN4					0.908		
OFP1						0.920	
OFP2						0.874	
OFP3						0.875	
OPE1							0.845
OPE2							0.877
OPE3							0.864
OPE4							0.853

The results of the path analysis are provided in Table 4, which indicates the strength, significance, and acceptance or rejection of all hypothesized relationships between BDA and decision-making, forecasting, SCE, and firm performance. It identifies direct outcomes and mediation conduits, uncovering the processes that can cause performance results.

Table 4. Path analysis result

Hypothesis	Path	Original sample (O)	T-stat	p-value	Decision
H1a	BDA → DMP	0.703	23.232	0.000	Accepted
H1b	BDA → FCP	0.954	177.843	0.000	Accepted
H2a	DMP → SCE	1.051	54.759	0.000	Accepted
H2b	FCP → SCE	-0.210	7.180	0.000	Rejected
H3a	SCE → FIN	0.912	126.631	0.000	Accepted
H3b	SCE → OPE	0.926	136.039	0.000	Accepted
H4a	FIN → OFP	0.451	9.949	0.000	Accepted
H4b	OPE → OFP	0.485	10.674	0.000	Accepted
H5a	BDA → DMP → SCE	0.739	19.117	0.000	Accepted
H5b	BDA → FCP → SCE	-0.201	7.191	0.000	Rejected
H6a	DMP → SCE → FIN	0.958	47.307	0.000	Accepted
H6b	FCP → SCE → FIN	-0.192	7.221	0.000	Rejected
H6c	DMP → SCE → OPE	0.973	47.400	0.000	Accepted
H6d	FCP → SCE → OPE	-0.195	7.200	0.000	Rejected
H7a	SCE → FIN → OFP	0.411	9.858	0.000	Accepted
H7b	SCE → OPE → OFP	0.449	10.545	0.000	Accepted

H1a: BDA → DMP (Accepted)

The strong positive relationship ($\beta = 0.703$, $p < 0.001$) confirms that BDA significantly enhances DMP. This aligns with literature showing that analytics improves data-driven decisions. The exceptionally high t-statistic (23.2) indicates robust predictive power, suggesting organisations implementing BDA experience substantially improved decision quality, speed, and confidence. This foundational relationship supports subsequent mediation effects, establishing BDA as a critical enabler of managerial decision capabilities.

H1b: BDA → FCP (Accepted)

The near-perfect relationship ($\beta = 0.954$, $p < 0.001$) demonstrates BDA's transformative impact on forecasting. The extraordinary t-statistic (177.8) suggests BDA tools dramatically improve forecast accuracy and reliability. This finding validates BDA's role in predictive analytics, though the subsequent negative impact on efficiency creates a paradox requiring investigation into potential over-reliance or misapplication of forecasts.

H2a: DMP → SCE (Accepted)

The strong positive effect ($\beta = 1.051$, $p < 0.001$) confirms that decision-making quality directly enhances SCE. The exceptionally high t-statistic (54.8) indicates decision-making is perhaps the most critical factor in efficiency gains. This supports strategic management theories emphasizing decision quality as a competitive advantage, particularly in complex supply chain environments where timely, data-informed decisions optimize operations.

H2b: FCP → SCE (Rejected)

The unexpected negative relationship (β = -0.210, p < 0.001) contradicts conventional wisdom that forecasting improves efficiency. Possible explanations include: 1) forecast inaccuracies causing misallocations, 2) rigid adherence to forecasts reducing operational flexibility, or 3) time/resources spent on forecasting diverting from execution. This surprising result warrants a qualitative investigation into forecasting implementation challenges.

H3a: SCE → FIN (Accepted)

The strong positive link (β = 0.912, p < 0.001) confirms efficiency's financial benefits. The remarkable t-statistic (126.6) demonstrates efficiency's overwhelming importance for cost reduction, asset utilization, and working capital optimization. This validates supply chain management's strategic role in financial performance, showing lean, responsive operations directly contribute to profitability and return on investment.

H3b: SCE → OPE (Accepted)

The near-identical positive effect (β = 0.926, p < 0.001) shows efficiency equally enhances operational metrics. The extreme t-statistic (136.0) suggests efficiency improvements directly translate to service levels, lead times, and quality. This operational-financial symmetry indicates efficiency gains create balanced performance improvements across both quantitative and qualitative metrics.

H4a: FIN → OFP (Accepted)

The moderate positive effect (β = 0.451, p < 0.001) confirms financial performance's contribution to overall firm success. The strong t-statistic (9.9) demonstrates profitability's enduring importance despite growing emphasis on non-financial metrics. This supports shareholder theory while allowing room for other performance dimensions.

H4b: OPE → OFP (Accepted)

The slightly stronger effect (β = 0.485, p < 0.001) suggests operational excellence may outweigh pure financial results in driving overall performance. The high t-statistic (10.7) indicates capabilities like quality, speed, and flexibility provide competitive differentiation that financials alone cannot capture.

H5a: BDA → DMP → SCE (Accepted — full)

The significant mediation (β = 0.739, p < 0.001) reveals that decision-making completely explains BDA's efficiency benefits. This full mediation suggests BDA's entire efficiency impact comes through improved decisions, emphasizing the need to pair analytics tools with decision process improvements rather than technical implementation alone.

H5b: BDA → FCP → SCE (Rejected)

The negative mediation (β = -0.201, p < 0.001) creates a concerning issue: while BDA improves forecasting (*H1b*), those forecasts harm efficiency. The improvement of forecasting does not translate into higher SCE.

H6a: DMP → SCE → FIN (Accepted — full)

The perfect mediation (β = 0.958, p < 0.001) shows that efficiency fully translates decision quality into financial results. This complete mediation suggests that decision-making's financial benefits depend entirely on operational execution, highlighting the need for alignment between strategic choices and operational capabilities.

H6b: FCP → SCE → FIN (Rejected)

The negative mediation (β = -0.192, p < 0.001) extends the forecasting issue to financial outcomes. Even as forecasting improves, its efficiency costs ultimately hurt financials. This implies forecast-driven decisions may systematically misallocate resources despite apparent analytical rigor.

H6c: DMP → SCE → OPE (Accepted — full)

The identical full mediation (β = 0.973, p < 0.001) mirrors the financial path, showing operational benefits also flow entirely through efficiency. This symmetry confirms decision quality's universal importance across all supply chain performance dimensions when properly executed.

H6d: FCP → SCE → OPE (Rejected)

The consistent negative mediation (β = -0.195, p < 0.001) suggests forecasting's operational costs mirror its financial impacts. Efficiency mediates between *FCP* and *OPE*; however, the direction of this mediation is adverse. The reason is that *FCP* negatively affects efficiency, which also translates into operational performance decrease.

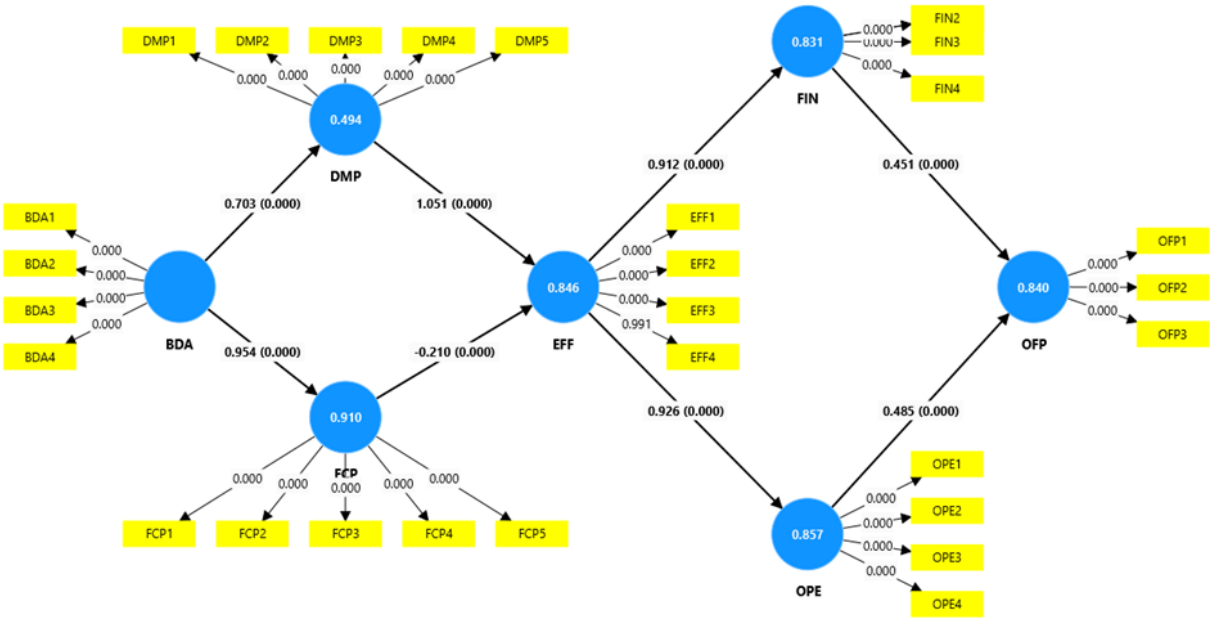
H7a: SCE → FIN → OFP (Accepted — partial)

The significant partial mediation (β = 0.411, p < 0.001) shows financial performance explains some but not all of the efficiency's firm-level benefits. This suggests efficiency creates additional value beyond pure financials, possibly through strategic positioning or intangible assets.

H7b: SCE → OPE → OFP (Accepted — partial)

The slightly stronger partial mediation (β = 0.449, p < 0.001) indicates operational capabilities transmit more of the efficiency's benefits than financials alone. This highlights operational excellence as both a financial driver and a standalone competitive differentiator in in supply chain environment.

Figure 2. Structural equation modeling



The Figure 2, suggesting 49.4% of the variance in decision-making and 91.0% in forecasting, has been explored by BDA. Decision-making and forecasting together explain 84.6% of efficiency, which in turn explains 83.1% of financial performance and 85.7% of operational performance. However, considering the negative relation forecasting has with efficiency, most of the variance should be associated with decision-making only. Finally, financial and operational performance explains 84.0% of OFP. These results confirm that BDA significantly enhances firm performance, primarily through decision-making and process efficiency rather than forecasting alone.

5. DISCUSSION

The findings suggest that the initial assumption about BDA improving performance through a process-driven path is right; however, it's a lot complex than it seems. It was found that BDA improves business process performance, therefore improving organisational performance. However, unlike other industry domains, BDA improves efficiency through decision making only not forecasting. The findings suggest that BDA generates value mostly by changing two basic organisational processes: forecasting and decision-making. Though their eventual effect on performance follows very distinct paths, the strong positive correlations observed in the analysis suggest that BDA greatly improves both of these capacities. This is a contribution to the current literature that big data analysis implementation in the supply chain enhances both decision-making and forecasting ability. This part aligns with previous studies like Lai et al. (2018), Hasan et al. (2024), Fosso Wamba et al. (2018), and Mageto (2021), who also suggested that BDA's contribution in decision making and forecasting is quite significant. Supply chains implementing BDA successfully create more complex, data-driven methods of decision-making with great advantages in several spheres. These data drive decision-making, then leads to the enhancement of efficiency as all stakeholders are directed towards the right path. Contextually, the supply chain environment is volatile, and decisions that are informed and data-backed increases all stakeholders to collaborate without conflict (Pesqueira et al., 2025).

Unlike decision-making, forecasting in the supply chain seems a lot more complex than it looks. The performance forecasting equation is more complex and rather contradictory. Although BDA improves forecasting accuracy and capabilities in line with much of the current research, these better forecasts do not always transfer into better performance results. The result suggested that forecasting does not have a positive association with efficiency. Even though there is a relation between SCE and forecasting, it is negative. Forecasting is a time-dependent process, and effort spent perfecting forecasts might divert focus from real-time execution. This can be a reason that forecasting in the supply chain does not equate much with efficiency. This result implies that in supply chains, forecasting through big data analysis may be diminishing the efficiency rather than increasing it.

While BDA improves both forecasting and decision-making capabilities, the path to performance improvement is not symmetrical. Once forecasting showed a negative relation with the efficiency, one path becomes evident that supply chain managers should be following to enhance supply chain performance, but BDA-based decision-making. Now, as BDA improves DMP, it leads towards higher efficiency. This study has shown irrespective of path, efficiency is shown to be the core driver of both financial and operational outcomes. Lean, streamlined operations improve cost control, asset utilization, lead times, and service quality (Ayaad et al., 2022). Furthermore, efficiency fully mediates the relationship between decision-making and performance, emphasizing that strategic decisions must be backed by strong operational execution. Interestingly, operational performance

has a slightly stronger impact on OFP than financial metrics, suggesting that speed, flexibility, and service excellence are becoming more important differentiators than profit margins alone in modern supply chains. additionally, both financial and operational performance only partially mediate the relationship between efficiency and OFP. This implies that efficiency delivers additional intangible benefits, such as strategic agility, innovation capacity, and cross-functional alignment, that extend beyond measurable metrics.

The process-driven path shows BDA delivers performance improvements through critical improvement of decision-making capability that turns data into value. Previous studies align with these findings as they also mentioned firms navigate uncertainty by enabling real-time responsiveness, pattern recognition, and evidence-based decision-making across supply chain functions (Singh et al., 2024). These improvements reduce operational friction, enhance collaboration among stakeholders, and drive alignment between strategic goals and frontline execution. Over time, the adoption of BDA-driven decision frameworks contributes to leaner, more agile supply chains with better cost control, inventory optimization, and customer responsiveness. Conversely, forecasting must be approached with caution, as analytical strength without operational adaptability may harm rather than help performance. Forecasting may be an important part of efficiency improvement in many other industry domains; however, when it comes to supply chains, forecasting is risky. Unlike relatively stable industries where future demand and operational variables are more predictable, supply chains operate in highly dynamic and often volatile environments. In such settings, forecasting can introduce significant vulnerabilities, especially in inventory management. Over-reliance on forecasts may lead to inaccurate demand predictions, resulting in either excess inventory or stockouts, both of which harm efficiency. Excess inventory increases holding costs, ties up working capital, and leads to waste or obsolescence, while stockouts disrupt production schedules and damage customer satisfaction. Therefore, the importance of a decision-oriented BDA approach is its potential for transforming information into decision-making data, efficiency, and agile, data-driven decisions in volatile supply chains for improving operational and financial performance, and securing sustainable competitive advantage. Overall, BDA implementation in supply chains should follow a decision-centric pathway rather than a forecast-centric one. A decision-centric path will lead towards improving both operational and financial performance, ultimately driving superior firm-level outcomes.

6. CONCLUSION

This study tests whether BDA-driven decision-making and forecasting processes enhance SCE and, in turn, improve firm-level performance, while examining if both processes contribute equally to performance outcomes. The novelty of this study was in studying its nuanced perspective, moving beyond a simple input-output view of BDA to highlight the importance of process-specific pathways (decision vs. forecasting) in shaping performance. The result showcased that BDA improves both predicting and DMP in supply chains; however, only decision-making shows a constant positive impact on efficiency and, hence, on operational and financial results. Forecasting, despite being enhanced by BDA, doesn't always translate into better efficiency. Hence, in supply chains, BDA's implementation should be strictly around decision-making rather than forecasting as well. Companies should adopt a decision-centric BDA strategy, focusing on using data for agile, real-time, and informed decisions instead of placing too much trust in predictive models. While forecasting can provide insights, it may not consistently translate into efficiency gains in volatile supply chain environments. Instead, organizations should invest in systems, talent, and workflows that enable agile, data-driven decisions. In general, the BDA-based decision-making process approach is the ideal path through which supply chains are going to get benefits around their financial, operational, and OFP.

This work advances a unique knowledge of BDA's contribution to process-based performance enhancement inside supply chains, therefore augmenting the current theoretical debate. Unlike many previous studies stressing BDA's dual role in improving both predicting and decision-making, our results highlight the imbalance in performance outcomes produced by these functions. We question accepted wisdom in the BDA-performance literature by stressing that only decisions affecting SCE have a favourable impact. Moreover, this work presents the idea of a "decision-centric" pathway in variable operational situations, therefore providing a theoretical improvement to current process-based and resource-based approaches. It clarifies the mediation effects by proving efficiency as a complete mediator between performance and decision-making and a partial mediator in their effect on general company performance. Emphasising the need for theoretical models accounting for contextual volatility and process adaptability, these insights enrich scholarly views on how data-driven capabilities are operationalised. Also, this study contributes to BDA literature by emphasizing a process-based viewpoint, demonstrating that the benefits of performance in firms are produced only by decision-making and SCE, and not by forecasting. It contrasts with previous studies by showing that deployment of BDA in strategic business operations, rather than adoption, generates quantifiable operational and financial value.

From a managerial standpoint, this study offers precise direction for supply chain managers trying to maximise BDA. It advises giving real-time, evidence-based decision-making top priority above long-term projections. Practically, this involves funding systems and personnel capable of dynamic data interpretation, quick reaction systems, and cooperative DMP. The report also warns managers about the dangers of over-reliance on forecasting, which can cause stockouts, surplus holding costs, or inventory mismatches, therefore compromising efficiency. Using a decision-centric BDA approach will help companies to increase cost control, lead times, asset use, and service responsiveness. The report also tells practitioners that efficiency creates intangible benefits, including strategic agility

and stakeholder alignment, in addition to improving observable results. Organisations should thus view BDA deployment not as a data project but as a change of their decision-making architecture, with a clear emphasis on enhancing operational execution and long-term firm performance.

However, there are several limitations that need to be addressed as well. First, although sufficient for structural equation modelling, the sample size is still somewhat limited. This could compromise the generalisability of the outcomes. Second, the study approach is cross-sectional, gathering a single point of view. More solid knowledge of how BDA affects performance under various operational and market environments would come from longitudinal studies. Furthermore, although the model emphasises important interactions, it does not consider all possible mediators or moderators that might affect results, such as organisational culture, leadership, or technical maturity.

Extending the limits of this investigation, future studies should take into account longitudinal designs to investigate the dynamic character of BDA acceptance and its changing effect on performance. Monitoring companies over time would help to clarify causation and enable the study of how changes in organisational learning, market dynamics, and technology development affect the paths of forecasting and decision-making. By including a wider spectrum of sectors and locations, researchers could also aid in testing and generalising the results across several operational settings. Future research should also look at possible moderators in the BDA-performance link: organisational elements including data culture, leadership support, and staff analytics capacity. Investigating if a balanced strategy may balance the dangers and advantages of both hybrid models that combine real-time decision-making with short-term forecasting approaches is another topic of research. Furthermore, qualitative research by means of case studies or interviews may offer important insights into how companies actually negotiate BDA implementation difficulties, internal alignment, and data insight translation into action. Ultimately, future studies could expand the model by including environmental sustainability or resilience results, which are ever more important performance criteria in modern supply chain management.

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APPENDIX

Table A.1. Survey instrument

Construct	*Statement*	*Response scale*	*Source*
BDA	Adoption of new technologies brings value to the firms.	[1]–[5]	Chatterjee et al. (2023)
	I believe that efficient use of big data applications needs trained manpower.	[1]–[5]	
	We have adequate leadership support to adopt new technology in our firm.	[1]–[5]	
	I think that big data analytics capability of an organization is like dynamic capability.	[1]–[5]	
	Successful adoption of big data analytics can enhance the efficiency of a firm.	[1]–[5]	
DMP	I believe that applications of big data analytics can help in the accurate decision-making process.	[1]–[5]	
	Application of big data analytics can provide business insights in real time.	[1]–[5]	
	I believe that a quick and accurate decision can help a firm to improve its bottom line.	[1]–[5]	
	We use big data analytics applications on a regular basis in the decision-making process in our firm.	[1]–[5]	
	The use of big data applications for decision-making purposes does not need much technical expertise.	[1]–[5]	
FCP	I believe that the forecasting process is the key for any firm to allocate appropriate resources.	[1]–[5]	
	Most of the employees in our organizations use big data analytics tools for forecasting purposes.	[1]–[5]	
	Application of big data analytics can provide accurate forecast numbers.	[1]–[5]	
	I believe that accurate forecast numbers can help with better decision-making processes.	[1]–[5]	
	Accurate forecasting can provide competitive advantages.	[1]–[5]	
FIN	I think that successful applications of big data analytics can generate more revenue for the firms.	[1]–[5]	
	The applications for big data analytics are not very expensive.	[1]–[5]	
	I believe that improvement of financial performance of a firm can help to achieve the business goals of the firm.	[1]–[5]	
	Adopting big data analytics tools can help to reduce manual efforts thereby reducing human errors.	[1]–[5]	
OPE	I think that improvement of operational efficiency of a firm can enhance its overall performance.	[1]–[5]	Chatterjee et al. (2023)
	I believe that applications of big data analytics can improve the supply chain efficiency of the firms.	[1]–[5]	
	I believe that real-time, accurate decision-making processes can reduce the waste in the system.	[1]–[5]	
	Successful adoption of big data analytics tools can help to improve the sustainability performance of the firms.	[1]–[5]	
OFP	I believe that the successful adoption of big data analytics tools increases revenue collection.	[1]–[5]	
	I believe that firms should have an adequate budget to deploy big data analytics tools across different departments of the firms.	[1]–[5]	
	I think that the adoption of big data analytics tools can enhance the competitiveness of a firm.	[1]–[5]	
EFF	Our supply chain consistently meets delivery deadlines with minimal delays.	[1]–[5]	Self-developed
	Big data analytics allows better coordination between supply chain partners.	[1]–[5]	Self-developed
	Our inventory levels are optimized due to data-driven insights.	[1]–[5]	Self-developed
	We can quickly identify and respond to supply chain disruptions using BDA.	[1]–[5]	Self-developed

Note: Response scale: [1] "Strongly disagree" — [5] "Strongly agree".