Impact of Industry 4.0 Capabilities on Supply Chain Performance in Developing Economies: Evidence from Sri Lanka's Apparel Industry

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Abstract

The apparel industry in developing economies faces significant challenges in digital transformation due to infrastructural limitations, skill gaps, and regulatory constraints. These barriers have hindered the full realization of the benefits offered by Industry 4.0 technologies. Drawing on capability-based theory, this study investigates how three key Industry 4.0 technological capabilities—Internet of Things (IoT), Big Data Analytics (BDA), and Cloud Computing (CC)—influence supply chain performance (SCP). Cross-sectional data from 57 apparel manufacturers in Sri Lanka were analysed using multiple regression analysis. The findings reveal that IoT and CC significantly enhance SCP, while BDA demonstrates a positive but statistically insignificant effect. This study contributes to the literature by providing sector-specific empirical evidence on the impact of Industry 4.0 capabilities in developing economies and extends capability-based theory within contexts characterized by structural and institutional challenges. Managerially, the study offers insights into how firms can leverage I4.0 technologies to strengthen SCP, even in resource-constrained settings. Limitations include the focus on a single industry and reliance on fundamental statistical techniques.

Keywords: *Big data analytics, Cloud computing, Internet of things, Apparel supply chain*

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Introduction

Globalisation and rapid technological innovation have shaped the modern corporate landscape, opening the era of Industry 4.0, which is characterised by linked, adaptive, and failure-proof technologies. (Rüßmann et al., 2015). Initially introduced in 2011 in Germany, Industry 4.0 has gained significant recognition in both the academic and business communities, where experts estimate its capability to improve productivity and quality of life (Oztemel & Gursev, 2020; Roblek et al., 2016). Nations around the world view Industry 4.0 as a strategic lever for national competitiveness and as a tool for national development, which has resulted in growing investments into Industry 4.0 projects that drive digitalisation (Koh et al., 2019; Oztemel & Gursev, 2020). Scholars are investigating the effect of these Industry 4.0 technologies and their capabilities across industries and markets on business operations and supply chains (Dallasega et al., 2018; Kamble et al., 2018; Lu, 2017; Nara et al., 2021).

As businesses face pressures from both internal and external environments, supply chains have gained significant focus for creating and capturing value. An integrated, transparent supply chain network not only enhances customer satisfaction but also improves the resilience of firms in the competitive business world (Wu et al., 2024). Industry 4.0 underpins this transformation through facilitating information sharing, which drives supply chain integration and transparency (Jia et al., 2024). Technological capabilities of Industry 4.0 technologies such as IoT, Cyber Physical Systems and RFIS have improved the real-time tracking and tracing, which improved the visibility and traceability (Alquraish, 2025; Tiwari, 2021). Findings from empirical studies shows that digital supply chains possess greater flexibility, collaboration, accessibility, and decision-making capability (Chauhan & Singh, 2020; Dallasega et al., 2018; De Vass et al., 2018; Dudukalov et al., 2021; Ghadge et al., 2020; Hald & Kinra, 2019; Mastos et al., 2021; Roblek et al., 2016)

Studies from developed contexts validate measurable gains from IoT, BDA, and CC adoption (Alquraish, 2025; Dalenogare et al., 2018; De Vass et al., 2018; Shee et al., 2018). However, several of the studies relating to Industry 4.0 technologies originate in resource-rich developed economies with robust digital infrastructure, advanced analytical capabilities, and supportive regulatory frameworks. In contrast, emerging market firms often face challenges due to connectivity gaps, skill mismatch, and legal and regulatory complexities that affect the technology-performance linkages (Koh et al., 2019).

The Sri Lankan apparel industry, though globally renowned for ethical practices (often termed as “guilt-free garments”) and high-quality products, operates under technological challenges due to a lack of strong digital infrastructure, analytical capabilities and rigid import-export regulatory compliance. These contextual factors can affect the ability to transform Industry 4.0 capabilities into competitive performance in supply chains. Most research is conducted in resource-rich economies. Hence, the extent to which the findings can be adapted to developing countries and industries is still questionable. This research investigates how the capabilities of three Industry 4.0 technologies (BDA, CC, and IoT) affect the SCP in the apparel industry. The study’s primary research question is: What is the impact of Industry 4.0 capabilities on Apparel SCP?

This study contributes to both theory and practice by (a) providing quantitative evidence on how IoT, CC, and BDA affect the SCP in the Sri Lankan Apparel Sector, (b) highlighting the effect of technological capability based on capability-based views, and (c) providing insights for managers to navigate and move forwards in digital transformation.

Literature Review

Industry 4.0

Industry 4.0, also referred to as the fourth industrial revolution, represents the transformation of digital and physical systems into interconnected systems that can adapt to changes and avoid failures through real-time data (Dudukalov et al., 2021; Rüßmann et al., 2015; Xu et al., 2018). Industry 4.0 comprises technologies such as IoT, BDA, CC, robotics, additive manufacturing, augmented and virtual reality (AR and VR) and cyber security (Oztemel & Gursev, 2020; Xu et al., 2018). Thus, experts argue that these interconnected technologies can improve the productivity, quality and agility through seamless information flows, decentralised decision-making and predictive maintenance (Bai et al., 2020). This has led to increased attention from scholars and practitioners, stimulating both theoretical and national-level digitalisation initiatives. Several nations have invested in Industry 4.0 projects aiming to improve processes and performance (Koh et al., 2019).

Empirical studies from resource-rich economies provide compelling evidence for the improvement in performance and efficiency due to the adoption of Industry 4.0 technologies (Dalenogare et al., 2018; Fettermann et al., 2018). Studies also reveal that CC enables real time information sharing across the supply chain, leading to a reduction of the bullwhip effect and improving the supply chain effectiveness (Ghadge et al., 2020; Shee et al., 2018). Yet the majority of these studies are based in nations and contexts characterised by well-established digital infrastructure, mature regulatory frameworks and abundant resource pools. In contrast, emerging markets and developing economies face challenges in terms of infrastructure challenges, lack of regulatory frameworks, and lack of skilled workforce that affect the adoption of Industry 4.0 technologies (Koh et al., 2019; Oztemel & Gursev, 2020). (Koh et al., 2019) highlights various digitalisation projects undertaken by nations. However, it is also highlighted that firms require strategies to absorb the digital capabilities by bridging the national strategies to technological capabilities.

While strong evidence shows the link of Industry 4.0 technologies towards operational performance in developed economies (Bai et al., 2020; Dalenogare et al., 2018), their relevance in the Sri Lankan apparel sector remains exploratory (Kulandaivel & Bandara, 2024). Highlighting this disparity, scholars highlight the need for more contextual research that explains the industry-specific conditions of adoption and effectiveness of Industry 4.0 technologies.

Preliminary studies on the diffusion of Industry 4.0 technologies in Sri Lanka present that IoT, CC and BDA are technologies that reflect a higher adoption level compared to other Industry 4.0 technologies in the Sri Lankan apparel industry, making these technologies key levers for SCP (Sachin & Bandara, 2021).

Cloud Computing

CC is the technology that permits the use and storage of applications, data, and other programmes in a virtual environment using the internet (Oztemel & Gursev, 2020; Xu et al., 2018). CC offers scalable access to storage, processing power, and application services via the internet, allowing organisations to minimise the technological investments while maximising the flexibility (Oztemel & Gursev, 2020; Xu et al., 2018). In supply chain management, CC serves as a hub for collaboration through shared inventory data, forecasting and order tracking on cloud platforms that improve transparency and timely decision-making (Fatorachian & Kazemi, 2021; Shee et al., 2018). Empirical evidence from developed contexts confirms that CC adoption supports supply chain integration and performance (Fatorachian & Kazemi, 2021; Shee et al., 2018).

Studies highlight that the challenges, such as lack of internet stability, regulatory frameworks and limited governance, can undermine the capabilities of CC (Shee et al., 2018). Studies in Sri Lanka show that only a few apparel exporters invest in cloud-based ERP modules and cloud analytics, highlighting concerns on security and supply risks (Sachin & Bandara, 2021). Few studies systematically measure the capabilities of CC, the ability of a firm to deploy and integrate cloud-based services for performance improvement. Moreover, limited research addresses the link between CC and SCP in developing economies and with specific reference to the apparel sector.

Internet of Things

IoT integrates sensors, actuators and networks for real-time tracking and automation (Kamble et al., 2018). IoT technology can be adopted across several fields, such as infrastructure, the health sector, logistics, and security (Roblek et al., 2016). Across the supply chain, IoT can improve the traceability and quality control, data sharing across the supply chain, and improve efficiency (Abdallah et al., 2025; De Vass et al., 2018; Fettermann et al., 2018; Hermann et al., 2016; Shah et al., 2019). IoT allows devices and sensors to interact in real time, allowing them to capture, process and communicate data, enhancing the coordination and synchronisation of data and information flow (Kamble et al., 2018).

Koh et al., (2019) cited IoT enables collaboration between diverse stakeholders through remote operations and improves responsiveness to environmental changes. Due to the mass customisation trend, IoT significantly improves the organisations' and customers' value. The application of IoT facilitates innovations in the manufacturing and services industries. It also develops new business models (Roblek, Meško and Krapež, 2016; Xu, Xu and Li, 2018). Several companies, such as automobile manufacturers, use IoT to reduce errors and improve production and product development (Fettermann et al., 2018). The findings of Fettermann et al. (2018) show that IoT is a technology widely implemented across several operations management areas, including manufacturing, quality management, supply chain, and JIT manufacturing.

Studies on IoT emphasise that IoT capability can enhance the value through integration across the supply chain (Shah et al., 2019). Studies on IoT validate that IoT significantly improves SCP across various sectors (De Vass et al., 2018, 2021; Pasi et al., 2020; Shah et al., 2019). However, such findings are mainly focused on developed economies. In developing economies, IoT adoption is confined to warehouse tracking, which lacks validation on how IoT capabilities can enhance the supply chain processes (Sachin & Bandara, 2021). Furthermore, limitations due to networking and connectivity, lack of regulatory support and technical challenges in developing economies place further constraints on capturing the full potential of the IoT capabilities (Sachin & Bandara, 2021; Wijewardhana et al., 2020)These barriers raise the question of what impact the IoT capabilities can have on SCP in the highly labour-intensive apparel sector.

Big Data Analytics

BDA exploits large amounts of data generated by diverse sources through digital processes (Oztemel & Gursev, 2020). BDA analyses the data through machine learning, statistical models and visualisation to gain insights and improve decision-making (Gunasekaran et al., 2017). Big data is used across several functions in an organisation. For example, organisations use BDA to track their customer behaviour through loyalty cards and forecast future trends in consumption, production planning, and purchasing decisions (Fosso Wamba et al., n.d.).

The analytical capability is measured through interoperable cross-functional databases, aggregated customer data that is widely available, advanced demand forecasting and process transparency and visualisation (Yu et al., 2018). The resource-based view presents data as a source of strategic advantage, as it contributes to organisational capabilities for real-time data analysis across diverse functions, improves predictive accuracy, and enhances responsiveness (Fatorachian & Kazemi, 2021; Yu et al., 2018). However, data quality plays a key role in the effectiveness of these technologies, as without quality data and a governance framework, the decision accuracy can degrade (Gunasekaran et al., 2004; Koh et al., 2019).

Sri Lankan apparel firms face challenges due to a lack of budgetary considerations for BDA, and a lack of analytically skilled personnel limits the use of data assets. Further, resistance from people for data sharing also limits the capabilities of BDA (Sachin & Bandara, 2021). While BDA is a key capability that can transform the business operation, empirical evidence from the emerging countries is scarce. Thus, it is essential to evaluate the role of BDA in enhancing the SCP in labour-intensive sectors such as the apparel sector in developing economies.

Supply Chain Performance

Supply chain management, referring to the aggregate effort to deliver the right product, in the right quantity, at the right time and at the right cost to the final consumer, has gained significant attention in the business world. More precisely, the concepts of sustainability and agility have become challenging themes in supply chain literature (Altay et al., 2018; Bourlakis et al., 2014; Chowdhury et al., 2024; Datta, 2017; Esmaeilian et al., 2020; Najmi & Makui, 2012; Whitten et al., 2012). SCP assesses the competitiveness of a supply chain against rivals. The performance of a supply chain affects the performance of individual entities in the network. From an organisational perspective, the organisation's competitiveness relies on the ability of the firm to manage both its internal and external relationships. Thus, cooperation and coordination across diverse functions of the organisation and across firms in the supply chain are crucial for value creation. This has gained significant attention in both the academic and business communities to investigate the means of improving the supply chain integration and performance.

Dimensions such as reliability, responsiveness, flexibility, quality and efficiency are key sources for evaluating the performance of supply chains across various literatures (Bourlakis et al., 2014; Fatorachian & Kazemi, 2021; Najmi & Makui, 2012). Whitten et al. (2012) stated that the performance of the supply chain is measured based on the ability to deliver the right quantities of products demanded by the customers at the right quality and time and the ability to minimise the cost to the final customer. Flexibility improves collaboration across the supply chain by integrating real-time data across the supply chain, leading to better performance (Datta, 2017). An agile supply chain can contribute to the supply chain as it improves the risk management capabilities, leading to more resilient operations (Altay et al., 2018). Reliability, on the other hand, highlights the ability of the supply chain to meet the customer requirement as promised, and responsiveness highlights the ability to fulfil the customer requirement in a shorter time (Najmi & Makui, 2012). Enhancing the visibility and transparency across the supply chain can improve the above key performance metric and significantly improve firms' performance (Fatorachian & Kazemi, 2021).

Industry 4.0 technologies play a key role in enhancing the information sharing and transparency through effective communication (Fatorachian & Kazemi, 2021; Khan & Emon, 2025). Further, analytical capabilities of an organisation can be significantly enhanced with capabilities of Industry 4.0 technologies. Studies related to Industry 4.0 technologies and supply chains in developed economies reveal that digitalisation of processes affects the SCP (Dudukalov et al., 2021).Concerning the apparel industry, the digital competency in the fashion supply chain needs to be improved to capture the value through digital transformation (B. Wang & Ha-Brookshire, 2018).

Theoretical Background – Capability-Based View

The Resource Based View (RBV) for competitive advantage highlights that firms achieve competitive advantage by leveraging internal and external resources (H. Wang, 2014). However, scholars argue that RBV underplays the processes and routines through which the resources are mobilised and adapted to dynamic environments. This led to Capability Based View Theory, an extension to the RBV, that emphasises the firm's ability to integrate, build and reconfigure the organisation's competencies to respond to rapidly changing conditions (Johnson et al., 2016; Teece et al., 1997). As Wang (2014) cites, the organisation must deploy resources and develop capabilities and learning implicitly and explicitly to gain a competitive advantage. In the context of digital supply chains, dynamic capabilities include not only technological assets but also processes and practices that organisations undertake to transform the resources into performance outcomes (De Vass et al., 2018).

Challenges faced by emerging markets affect the efficacy of digital capabilities. Thus, this study adopts the capability-based view (CBV) that views IoT, CC and BDA not as static resources but as sources of dynamic capabilities that contribute to performance.

Sri Lankan Apparel Industry

The Sri Lankan apparel sector has been established for over 30 years and positions itself as a global leader in ethical manufacturing and compliance, contributing to global brands such as Nike, Tommy Hilfiger, and Marks and Spencer under rigorous social and environmental standards (Export Development Board - Sri Lanka, 2024a). The Sri Lankan apparel industry plays a key role in Sri Lankan national exports by contributing over 42% of the national merchandise exports and employing over 350,000 employees, making it a source of foreign exchange and employment for the nation (Export Development Board - Sri Lanka, 2024b; Sri Lanka Apparel Exporters Association, 2024a).

Apparel exports play a crucial role in supporting the economy's balance of payment and exchange stability. In addition, the apparel sector also contributes significantly to reducing unemployment. The Sri Lankan apparel industry has focused on accelerating the apparel sector to US $8 billion by 2025 (Sri Lanka Apparel Exporters Association, 2024b). Apparel firms also try to transform the industry toward an "end-to-end integrated apparel solution provider", intensify market penetration and improve their global presence (Sri Lanka Apparel Exporters Association, 2024b). Thus, focusing on performance improvement and improving the integration is important to achieve the expected future goals. However, the adoption of Industry 4.0 technologies is in its early stage, and a few selected technologies are being adopted in the Apparel Industry in Sri Lanka (Lakmali et al., 2020; Sachin & Bandara, 2021; Wijewardhana et al., 2020). Only a few studies have explained the importance of improving Industry 4.0 Capabilities for apparel firms.

Studies on Sri Lankan context Documents adoption traits and level of readiness for adopting Industry 4.0 technologies without highlighting how the capabilities of these technologies can have an impact on SCP (Lakmali et al., 2020; Sachin & Bandara, 2021). Studies related to quantitatively assessing how IoT, CC and BDA capabilities drive SCP under local contingencies. This gap highlights the need for a contextualized study combining validated instruments to produce a generalizable perspective on the emerging apparel market in Sri Lanka

Conceptual Framework and Hypothesis

Internet of Things and Supply Chain Performance

IoT technology improves real-time information sharing in real time. IoT is adopted across several sectors, such as healthcare, infrastructure, logistics, and security (Roblek et al., 2016). The IoT is one of the critical technologies in Industry 4.0, which improves connectivity and communication among devices, reduces the bullwhip effect, and improves traceability (Hermann et al., 2016). Devices such as RFID, GPS and trackers improve visibility and real-time monitoring across the supply chain and improve the information flow. It also facilitates machine-to-machine communication, predictive analytics, and human-machine interaction, leading to higher productivity and efficiency. Researchers have highlighted IoT as an additional capability for the organisation to improve the value across the supply chain and as a resource that improves the performance through integration across the supply chain (Shah et al., 2019). Researchers have also validated that IoT has a significant positive effect on supply chain integration, which improves SCP and organisational performance in several sectors (De Vass et al., 2018; Pasi et al., 2020).

Analysis of interviews provides evidence that the IoT contributes significantly to integration, information sharing, and transparency in SCP. Hence, IoT has an impact on the SCP. Accordingly, the following hypothesis can be formulated.

H 1 (a) - Internet of Things has a positive impact on Supply Chain Performance

Big Data and Analytics and Supply Chain Performance

Fatorachian & Kazemi (2021) define Big Data and Analytics as computing and analytical power offered by computers and analytical techniques against such a large and diverse data set. Big Data acts as a source of generating information and connectivity that improves organisation and SCP (Gunasekaran et al., 2017). Achieving efficiency and effectiveness in the supply chain requires higher access to data from different functions and participants across the supply chain (Yu, 2015; Yu et al., 2018). Adoption of BDA capability into the supply chain results in a data-driven supply chain which facilitates the firm to develop a collaboration with all supply chain participants and improves the efficiency

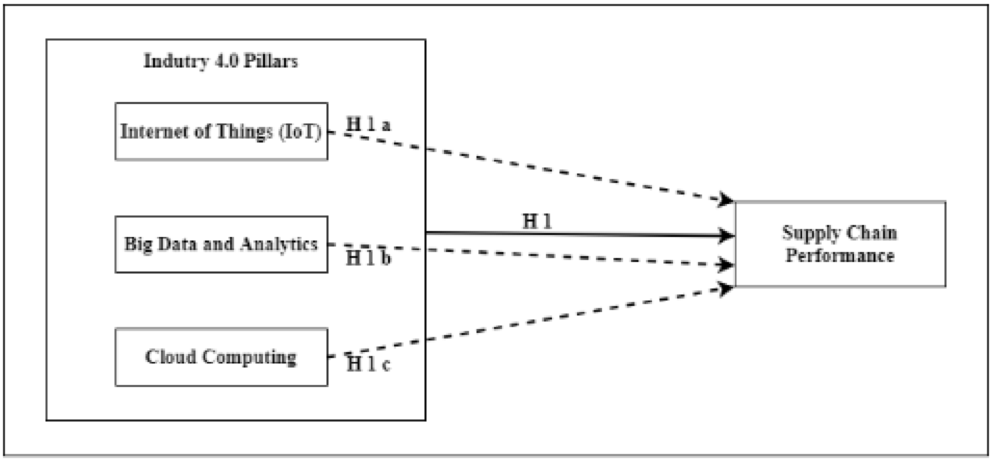

Figure 01: Conceptual Framework (Author Generated)

and responsiveness of the supply chain (Samuels & Pelser, 2025; Yu et al., 2018). The findings of Yu et al. (2018) show that the data-driven supply chain has a significant positive impact on the supply chain for information exchange, coordination, integration, and responsiveness.

Further, Big Data and Analytics contributed to cost reduction and lead time reduction. Further, big data also contribute towards integration and information sharing across the supply chain. Hence, Big Data and Analytics has an impact on SCP. Accordingly, the following hypothesis can be formulated.

H 1 (b) - Big Data and Analytics has a positive impact on Supply Chain Performance

Cloud Computing and Supply Chain Performance

CC helps access data and information from virtual servers using the Internet anywhere. CC enables real-time access to extensive data (Ghadge et al., 2020). Cloud technologies improve data sharing and support. This system helps reduce cost, reduce infrastructure complexity, and easily protect data and access information (Oztemel & Gursev, 2020). Cloud manufacturing is a similar technology used extensively by the manufacturing industry, which improves networking and resource sharing (Xu et al., 2018). The findings from Shee et al. (2018) emphasise that cloud technology positively affects supply chain integration and supports SCP. CC aims to improve information sharing, process improvement, and transparency. Hence, CC has an impact on SCP. Accordingly, the following hypothesis can be formulated.

H 1 (c) - Cloud Computing has a positive impact on Supply Chain Performance

Methodology

The study aims to assess the impact of selected Industry 4.0 technological capabilities on SCP. A survey approach was employed to address the research problem. Following a quantitative approach to collect and analyse data through survey questionnaires, the study statistically assesses the impact and answers the research questions. The study population comprises the BOI-registered apparel manufacturers in Sri Lanka. The data for the study was drawn from supply chain managers, operations managers, and general managers of the apparel firms via an online survey. A survey questionnaire (Appendix 1) was developed to collect

Table 01: Operationalization of Variables

Construct	Source(s)	Items
IoT Capabilities	Kamble et al. (2018); Shah et al. (2019)	5
BDA Capabilities	Fatorachian & Kazemi (2021); Yu et al. (2018)	4
CC Capabilities	Shee et al. (2018); Oztemel & Gursev (2020)	8
SCP	Najmi & Makui (2012); Whitten et al. (2012)	11

data to test the hypothesis shown above, consistent with existing literature (De Vass et al., 2018; Shee et al., 2018; Whitten et al., 2012; Yu et al., 2018). The researcher used a five-point Likert scale for all measurement items.

A pilot survey of 30 respondents representing the organisations was conducted before using the questionnaire in the final survey. The final survey questionnaire was distributed after ensuring its validity and reliability. The study population comprises 350 BOI-registered apparel manufacturers in Sri Lanka. However, not all manufacturers have adopted Industry 4.0 technologies in their operations. Hence, organisations which have adopted Industry 4.0 have been identified as the target population for the study for better analysis. A list of the potential respondents from each of these organisations was prepared. The link for the online survey was emailed to a senior supply chain or operations manager per firm.

Each response from responding organisations was screened, and firms that have not adopted selected Industry 4.0 technologies (IoT, CC and BDA) were eliminated. 57 usable responses were finalised for the analysis. Multiple Regression analyses were performed using SPSS 22 to investigate and test the study's hypothesis.

Findings and Discussion

Validity and Reliability

The reliability of the measures was ensured using Cronbach's alpha. The coefficient for all measures is above 0.7, as summarised in Table 02 below.

The construct validity of the measures is ensured using the Exploratory Factor Analysis. The KMO measure of sampling adequacy for all variables is above 0.7, ensuring the sample is adequate and suitable. The Bartlett's Test for Sphericity for all variables was significant at $p < 0.05$.

Hypothesis Tests

Across all the constructs, the skewness and kurtosis values remain under +/- 1, conforming to the normality of the data. Further, Pearson correlations confirmed significant bivariate relationships between SCP and predictors (IoT, CC and BDA). Table 04 shows the correlation analysis highlighting moderate to strong correlations between the dependent and independent variables. Tests were undertaken to assess whether data met all the assumptions for multiple linear regression. Tests ensured the independence of observation, normality, linearity, homoscedasticity, and no multicollinearity. Hence, the researcher met all the multiple linear regression assumptions.

Table 02: Reliability Test

Variable		Number of items	Cronbach's Alpha
IV	**IoT**	5	0.887
	BDA	4	0.851
	CC	8	0.922
DV	**SCP**	11	0.945

Table 03: Demographic Analysis

Respondents' Profile	**Sample (n=57)**		**Company Profile**	**Sample (n=57)**	
	Frequency	**%**		**Frequency**	**%**
Gender			***Firm's Age***		
Male	41	71.9	<10 Years	5	8.8
Female	16	28.1	10-15 years	8	14.0
			16-25 years	18	31.6
			> 25 years	26	45.6
Education			***Firm Size (based***		
Bachelor's Degree	29	50.9	***on the number of***		
Master's Degree	27	47.4	***employees.)***	14	24.6
PhD	1	1.8	< 1000	9	15.8
			1000-2000	34	59.6
			> 2000		
Industrial Experience			***Fund allocation***		
< five years	3	5.3	***for innovation***		
5-10 years	26	45.6	< 5 %	14	24.6
11-15 years	9	15.8	5-10 %	25	43.9
> 15 years	19	33.3	10-15 %	13	22.8
			> 15 %	5	8.8
Designation					
CEO/GM/MD	15	26.3			
Operations Manager	7	12.3			
Supply Chain Manager	13	22.8			
Merchandising Manager	13	22.8			
Logistics Manager	4	7.0			
Senior Executive	5	8.8			

Table 04: Correlation Analysis

		IoT	BDA	CC	SCP
IoT	Pearson Correlation	1	.253	.440**	.554**
	Sig. (2-tailed)		.058	.001	.000
	N	57	57	57	57
BDA	Pearson Correlation	.253	1	.509**	.495**
	Sig. (2-tailed)	.058		.000	.000
	N	57	57	57	57
CC	Pearson Correlation	.440**	.509**	1	.655**
	Sig. (2-tailed)	.001	.000		.000
	N	57	57	57	57
SCP	Pearson Correlation	.554**	.495**	.655**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	57	57	57	57

**. Correlation is significant at the 0.01 level (2-tailed).

Table 05 summarises the model summary of the multiple linear regression analysis used to achieve the research objective by testing the study's hypothesis. Multiple linear regression with IoT, BDA and CC as predictors yielded $R^2 = 0.548$ ($F(3,53) = 21.40$, $p<0.001$), suggesting that dependent variables together explain 54.8% variance in SCP.

The below Table 08 summaries the hypothesis testing. Accordingly, IoT (H1a) and CC (H1c) exhibit significant positive effects on SCP with $p<0.05$. Thus, the null hypothesis is rejected. However, BDA (H1b) shows a positive but non-significant impact on SCP ($p>0.05$).

Discussion

The analysis revealed that IoT and CC capabilities significantly influence SCP among Sri Lankan apparel manufacturers. However, BDA capabilities, though positively related, do not achieve statistical significance. The findings align with (De Vass et al., 2018; Shah et al., 2019), which highlight IoT's critical role in improving real-time visibility, coordination and integration across the supply chain. Similarly, (Fatorachian & Kazemi, 2021; Shee et al., 2018), Shown that cloud-enabled process integration can strengthen information sharing and operational responsiveness that contribute to SCP.

The effect of BDA on SCP in our study contradicts existing studies in resource-rich economies (Babu et al., 2021; Samuels & Pelser, 2025) that report a strong relationship between analytical capabilities and performance (Yu et al., 2018). This divergence can be explained with several contextual barriers faced in the Sri Lankan apparel sector. First, firms that lack a robust data governance framework, cross-functional data warehouse access and resistance to adapting analytical practices among staff undermine the effectiveness of analytical capabilities (Sachin & Bandara, 2021). Further lack of investment and training in improving analytical skills and integration

Table 05: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.740[a]	.548	.522	.50470	.548	21.404	3	53	.000

a. Predictors: (Constant), CC, IoT, BDA

Table 06: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.357	3	5.452	21.404	.000[b]
	Residual	13.500	53	.255		
	Total	29.857	56			

a. Dependent Variable: SCP
b. Predictors: (Constant), CC, IoT, BDA

Table 07: Coefficients

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.491	.420		1.170	.247
	IoT	.341	.109	.323	3.136	.003
	BDA	.176	.092	.206	1.919	.060
	CC	.372	.105	.408	3.528	.001

a. Dependent Variable: SCP

Table 08: Hypothesis Testing

Hypothesis	β (Standardized Coefficient)	t-Statistic	p-Value	Decision
H1a	0.323	3.136	0.003	Supported ($p < 0.05$)
H1b	0.206	1.919	0.060	Not Supported ($p > 0.05$)
H1c	0.408	3.528	0.001	Supported ($p < 0.05$)

challenges due to legal systems' poor connectivity could lead to this insignificant effect. These factors support the findings highlighted by (Koh et al., 2019), where data quality and qualified data analysis capabilities are key to achieving desired outcomes in BDA.

The regression model explains 54.8% of the variance in the dependent variable, SCP, which highlights the effect of unmeasured factors and variables in the model. Potential variables that could have an impact on the dependent variable may include human factors, organisational culture, digital readiness and maturity of collaboration.

Conclusions

While researchers and the business community suggest that Industry 4.0 capabilities have the potential to improve the competitiveness of organisations across the supply chain, studies that empirically support the viewpoint are scarce. This study fills the gap by examining how three selected Industry 4.0 capabilities – IoT, CC and BDA – affect SCP in the Sri Lankan apparel industry. Findings reveal that IoT and CC capabilities significantly enhance SCP. However, BDA fails to meet the statistical significance though there is a positive correlation.

Theoretically, the results refine and support the capability-based view by demonstrating that digital capabilities contribute to SCP. This highlights that capability does not always uniformly translate into supply chain gains under emerging market constraints. IoT and CC emerge as capabilities when supported by basic infrastructure. BDA requires further organisational investment and training to yield measurable benefits. Practically, the findings provide insights to managers related to digital investments to prioritise networking and cloud capability collaboration to secure better performance and to governance frameworks and talent development to unleash the BDA capabilities.

The study only addresses the impact on SCP in the apparel industry. Thus, the findings cannot be generalised. Future research could be performed in different industries, and such findings can explain how these technologies can affect different industries. The framework does not consider any mediating or control variables that can affect the relationship between the technologies and SCP. Studies can be performed by developing frameworks that assess the model with mediating or control variables. The study did not investigate the causes of the insignificant impact of BDA; instead, it tested the impact using a simple statistical test to check the hypotheses. Future studies with a complex model and a critical statistical test to test hypotheses can be performed.

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