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Intellectual Capital and Supply Chain Resilience: An interplay of Supply Chain Integration and Data Driven Culture

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Abstract
This research investigates the influence of Intellectual Capital (IC) on Supply Chain Resilience (SCR), with Supply Chain Integration (SCI) serving as a mediator and Data-Driven Culture (DDC) as a moderator, through the lens of Dynamic Capability view. Adopting a quantitative design, the research employed structured questionnaires to collect primary data from professionals in the telecommunication sector in Rawalpindi and Islamabad, Pakistan. A total of 239 valid responses were obtained using non-probability, convenience sampling. Statistical analysis was conducted using regression-based techniques to examine direct, mediating, and moderating effects. The findings reveal that IC significantly enhances SCR, demonstrating that organizations leveraging human, structural, and relational capital exhibit greater resilience. Although SCI positively influences SCR, its role as a mediator between IC and SCR was not statistically significant, suggesting that IC directly contributes to resilience, independent of integration mechanisms. However, DDC was found to significantly moderate the IC-SCR relationship, amplifying the impact of IC in data-driven environments. This research contributes novel insights by underscoring the strategic role of IC and data-driven decision-making in fostering resilient supply chains. The study offers practical implications for policymakers and managers aiming to build adaptive capabilities in volatile operational contexts.

Keywords: *Intellectual Capital, Supply Chain Resilience, Supply Chain Integration, Data Driven Culture*

1. Introduction

In recent years, persistent irregularities in politics, economy, society, and technological structures have necessitated that organizations enhance their intangible dynamic capabilities, particularly by investing in knowledge resources (Dabić et al., 2021, p. 67). Due to the adverse impacts of COVID-19 on supply chain efficiency, enterprises are increasingly implementing supply chain mapping as a strategic method to create a stable and resilient supply chain (Ali, Mubarik, & Nazir, 2021). COVID-19 is merely one instance of a crisis that creates uncertainty, ambiguity and disorientation in the business environment. Companies need to develop resilience to be competitive when times are uncertain (Župerkienė, Šimanskienė, Labanauskaitė, Melnikova, & Davidavičienė, 2021).

The current study defines resilience as "the ability to prepare for and effectively respond to crises; maintain core functions when a crisis hits; and, informed by lessons learnt during the crisis, reorganize if conditions require it" (Agostini & Nosella, 2017). Intellectual capital is seen as a key enabler of proactive supply chain management (Al-Omoush, Palacios-Marqués,

& Ulrich, 2022). IC is a repository of acquiring knowledge and invention that is always producing new information for responding to crises and emergency situations. When uncertainties occur, collaboration is the only way for businesses and their supply networks to survive (Agostini & Nosella, 2022). In times of crisis, businesses must act fast to coordinate with their supply chain partners and collaborate on their aggregate skills, benefiting from one another in order to generate novel knowledge in response to unforeseen fluctuations in market demand and supply. Shared creation of knowledge is now critical to dealing with the uncertainties. Intellectual capital management is a key factor in fostering the spirit of knowledge creation through partnerships with business partners, hence boosting supply chain cohesiveness and authenticity (Al-Omoush et al., 2022).

In this approach, intellectual capital can help organizations prepare for risk and unexpected events. Consequently, the firm could have the capability to monitor the movements of products or services in instantaneously, so providing a competitive edge and enhancing value creation (Ali et al., 2021).

Enhancing business adaptability can boost preemptive flexibility in solving supply chain issues and reactive reaction in developing supply and demand flexibility, that shifts abruptly and inevitably (Raj, Mukherjee, de Sousa Jabbour, & Srivastava, 2022). However, prolonged exposure to volatile markets demands not only internal knowledge capabilities but also collaborative, integrated systems that enhance flexibility and performance under pressure. Supply chain integration enhances the capability of an organization to respond more rapidly to market demands. (Siagian, Tarigan, & Jie, 2021). Supply chain integration, encompassing supplier, customer, and internal integration, can enhance resiliency and competitiveness in the marketplace(Rashid, Rasheed, Ngah, & Marjerison, 2024; Tarigan, Siagian, & Jie, 2021).

Intellectual capital facilitates supply chain integration by promoting collaboration among partners, fostering mutual learning, and generating solutions. Possessing robust human, structural, and relational capital inside an organization facilitates seamless communication as well as coordinates all activities, hence enhancing the effectiveness of Supply Chain Integration (SCI) (Hsu, Yang, Zhang, Chang, & Zheng, 2021). As a result, SCI strengthens supply chain stability by offering better insight, better coordination and more flexibility, helping organizations react effectively to upsets as they occur (Wieland & Wallenburg, 2013) When supply chains are integrated, employees handle operations and risks together, making systems more flexible in changing environments (Odukoya, 2019).

With the rise of data analytics and digitization, Data-Driven Culture (DDC) has emerged as a strategic enabler in supply chains (Agrawal, Murthy, Kumar, Jain, & Agarwal, 2023; Yadav et al., 2024). Organizations that prioritize data in decision-making are better positioned to harness the latent value of IC (Al-Khatib, 2022; De Santis & Presti, 2018), transforming insights into real-time strategic actions (de Oliveira & Handfield, 2022).

Studies have explored the impact of data-driven capabilities on organizational performance and innovation. D. T. Wong and Ngai (2023) found that analytics capabilities positively influence operational performance, with DDC moderating this relationship. Similarly, X. Liu, Li, Wang, and Zhang (2025) demonstrated that data-driven supply chain orientation enhances innovation performance through dynamic and improvisational capabilities (Aljehani, Abdo, Nurul Alam, & Aloufi, 2024) . Y. Liu, Fang, Feng, and Gao (2022) showed that big data analytics (BDA) capabilities enhance green SCI, with data-driven decision culture playing a moderating role. These studies have emphasized on the importance of data-driven capabilities and culture in enhancing various aspects of the organizational performance, that includes operations, innovation, and supply chain management.

Although considerable attention has been devoted to the literature of supply chain resilience (Abourokbah, Mashat, & Salam, 2023; Agostini & Nosella, 2022; Ahangama, Prasanna, & Blake, 2019; Al-Ayed & Al-Tit, 2023; Aldrighetti, Battini, & Ivanov, 2023; Aldrighetti,

Battini, Ivanov, & Zennaro, 2021; M. Ali, Nazir, & Junaid, 2023; M. H. Ali et al., 2021; Asamoah, Agyei-Owusu, & Ashun, 2020; Aslam, Khan, Rashid, & Rehman, 2020; Cheng & Wang, 2024; Craighead, Blackhurst, Rungtusanatham, & Handfield, 2007; El Baz & Ruel, 2021; Ivanov & Das, 2020; Qader, Junaid, Abbas, & Mubarik, 2022; Spieske & Birkel, 2021), notable gap persists in understanding how IC, SCI, and DDC interact to build resilience particularly in emerging markets like Pakistan. This study addresses this gap by examining how intellectual capital influences SCR, with SCI as a potential mediator and DDC as a contextual moderator, within the framework of the Dynamic Capability View thereby closing a gap in the current literature.

Using the Dynamic Capability View as a theoretical lens, the research illustrates how IC when reinforced by supply chain integration practices and data-driven culture becomes a transformative resource for building resilience. In doing so, the study extends the conceptual boundaries of DCV by incorporating intangible knowledge assets and cultural enablers into the resilience discourse. It offers practical insights for decision-makers on how to leverage intellectual capital and cultivate a data-centric culture to build more responsive, adaptive, and resilient supply networks. The study aims to examine the subsequent research questions:

RQ1: How does Data driven culture moderate the relation between Intellectual capital, supply chain integration and Supply Chain Resilience?

RQ2: Does supply chain integration mediate between Intellectual capital and Supply Chain resilience?

2. Literature

2.1 Dynamic Capability View

The Dynamic Capability View (DCV) provides a robust theoretical foundation for understanding the interplay between intellectual capital, SCR, SCI, and data-driven culture. In the context of study, we conceptualize that Intellectual capital comprises of human, organizational and relational assets that supports a firm's capability to deal with disruptions, enhancing the strength of its supply chain (Teece, Pisano, & Shuen, 1997). From a DCV lens, IC enhances a firm's sensing capability by enabling the identification of environmental risks and opportunities. It supports seizing opportunities through improved planning and decision-making, and it aids reconfiguring by cultivating knowledge-sharing structures that allow for rapid resource alignment (Teece et al., 1997). Therefore, IC is theorized to have a direct and positive influence on supply chain resilience (SCR). Supply Chain Integration (SCI) is positioned as a mediating mechanism that channels IC's influence into operational reality. Theorized as a capability that allows firms to synthesize knowledge and coordinate across internal and external stakeholders, SCI helps translate intangible knowledge (from IC) into process-level adaptability and cohesion (Wieland & Wallenburg, 2013). SCI, in turn, enhances SCR by improving firms' ability to jointly respond to disruptions, a notion consistent with the DCV emphasis on coordinated responses and resource orchestration (Agostini & Nosella, 2022; M. A. Ali, Hussin, Haddad, Alkhodary, & Marei, 2021; Eisenhardt & Martin, 2000).

The inclusion of Data-Driven Culture (DDC) as a moderator is theorized as a contextual enabler of dynamic capability execution. DDC reduces decision-making latency and enhances organizational reflexivity by embedding analytics and insights into day-to-day routines (Dubey, Gunasekaran, & Childe, 2019). Theorizing within DCV suggests that data driven culture amplifies the effect of IC and SCI on SCR by accelerating sensing and reconfiguration processes (X. Liu et al., 2025). Thus, DDC not only strengthens the IC–SCR linkage but also sharpens SCI's role as a resilience enabler.

The conceptual framework is actively theorized through DCV explaining why and how IC, SCI, and DDC interact to develop supply chain resilience. The model contributes to theory by

expanding DCV's scope to include data driven culture and knowledge-based resources, providing a holistic view of supply chain resilience in dynamic contexts.

2.2 Intellectual Capital and Supply Chain Resilience

"*IC includes an organization's processes, technologies, patents, employees' skills, and information about customers, suppliers, and stakeholder* (Stewart, 1995, p. 67)." Relational capital is made up of the knowledge located within relationships and networks (Adler & Kwon, 2002). It can be divided into two categories: external social capital (bridging) and internal social capital (bonding). According to Youndt, Subramaniam, and Snell (2004) , organizational capital forms from what is contained in a company's databases, manuals, lifeblood, systems and processes. IC helps supply the ongoing input that guidance a company's functioning (Song, Zhang, Shi, & Yin, 2024). Having strong human resources and making use of capital from collaborations with partner organizations is important (Cabrilo & Dahms, 2018). Research reveals that IC is important for driving value in businesses and for being a leader in market. (Kusi-Sarpong, Mubarik, Khan, Brown, & Mubarak, 2022; Song et al., 2024). Businesses with a strong base of intellectual capital are able to predict risks, cooperate within and outside their organizations and continue operating despite supply chain problems (Dubey et al., 2018). Having all relationships and knowledge combined helps in both proactive risk management and the ongoing growth of the company (Hosseini, Ivanov, & Dolgui, 2019).

Recent empirical studies affirm that intellectual capital (IC) significantly enhances supply chain resilience (SCR) by equipping firms with the knowledge assets necessary to anticipate, absorb, and adapt to disruptions (Zighan, Dwaikat, Alkalha, & Abualqumboz, 2024). Yu, Wong, Chavez, Jacobs, and Nittala (2023) demonstrated that human, social, and organizational capital each contribute uniquely to SCR, with organizational and social capital acting as mechanisms to mobilize embedded knowledge during crises. Similarly, Tu, Li, Dong, Zhou, and Hu (2025) confirmed a direct positive relationship between IC and SCR, emphasizing that firms with robust intellectual capital are better positioned to maintain operational continuity and recover swiftly from supply chain shocks (Tu et al., 2025). Therefore, it can be hypothesized that;

H_1: Intellectual Capital has a significant impact on Supply Chain Resilience.

2.3 Mediating Role of Supply Chain Integration

SCI means that companies and their stakeholders cooperate on both internal and external activities to ensure effectiveness in how products, services, information, capital and decisions are managed and transferred (Flynn, Huo, & Zhao, 2010). SCI is divided into three categories: customer integration (CI) , supplier integration (SI) , and internal integration (II) (Huo, Ye, Zhao, & Shou, 2016). Through sharing details and expanding expertise, SCI supports proper coordination between clients, suppliers and organizations from within the company (Song et al., 2024). Organizations apply SCI practices to provide added value, boost their results and enhance both their customer support and innovations (Alzoubi, Elrehail, Hanaysha, Al-Gasaymeh, & Al-Adaileh, 2022), generating a lasting competitive edge in fiercely competitive marketplaces (Siagian et al., 2021).

The presence of intellectual capital greatly helps to enhance a SC's ability to face and mitigate challenges (Alnasser, Alkhozaim, Alshiha, Al-Romeedy, & Khairy, 2024). Robust IC allows organizations to use their knowledge wisely, prepare for risks, introduce new approaches and maintain smooth operations(Yu et al., 2023). Still, the main effect IC has on SCR is usually connected to supply chain integration (SCI) which helps companies cooperate, share information and decide swiftly. SCI allows firms to join with businesses beyond their core teams, making the supply chain more adaptive and able to respond quickly to problems (Mubarik, Bontis, Mubarik, & Mahmood, 2022).

SCI refers to a process where a firm integrates all important parts in its operations, including supplier, customer and internal aspects (Huo et al., 2016). Internal integration ensures that all business functions are assigned responsibilities that help achieve and improve performance, meet customer needs and increase their satisfaction (C. W. Wong, Wong, & Boon-Itt, 2013; C. Y. Wong, Boon-Itt, & Wong, 2011). As a part of a business's strategy businesses build and retain long-lasting partnerships to enjoy the most rewards (Muafi & Sulistio, 2022). Cooperation between a business and its suppliers on the one hand and its customers (called external integration) helps organizations achieve effectiveness (Ataseven, Nair, & Ferguson, 2018; Flynn et al., 2010; Zhu, Krikke, & Caniëls, 2018).

Mubarik et al. (2022) claim that if firms have a lot of IC, they might not be able to transform their information into resilience benefits unless their supply chains are well integrated.. SCI supports more effective use of knowledge during decision-making and necessary operations(Qureshi et al., 2024). Also, with the help of SCI, businesses can receive and share live data to catch risks early and address them. As a result, organizations become better able to handle changes and react quickly to changes in supply chain needs.(Yu et al., 2023). This integration enhances resilience by reducing uncertainties and improving supply chain responsiveness.

Empirical evidence suggests that the impact of IC on SCR is increased when SCI improves how partners coordinate with each other (Mubarik et al., 2022). Intellectual assets can be used more successfully and favors teamwork and openness to new knowledge in organizations that have well-connected supply chains (Mubarik et al., 2022; Qureshi et al., 2024). Moreover, SCI makes it easy to transfer successful techniques and recent developments in technology throughout the supply chain which strengthens resilience. As a result, SCI acts as a helper and as a significant connector that helps IC benefit SCR to the greatest extent possible (M. Ali et al., 2023; Mubarik et al., 2022).

H_2: Supply Chain Integration Mediates the relation between Intellectual Capital and Supply Chain Resilience.

2.4 Moderating Role of Data Driven Culture

"Data-driven culture refers to the set of values, behaviors, and practices within the organization that prioritize the effective use of data" (Javed & Akhlaq, 2024). Organizations that invest in Intellectual Capital are better able to deal with shocks in their supply lines (Alnasser et al., 2024). But how well companies use data analysis depends much on how they organize their daily operations (Mubarik, Uziene, & Khan, 2021)). According to recent studies, organizations focused on data analytics use their knowledge efficiently for resilience and tend to predict problems, cooperate more and streamline how they allocate resources (Yu et al., 2023). Furthermore, research by Lin et al. (2025) found that using data leads organizations to develop insights in real time which helps them use their intellectual assets to strengthen supply chain resilience.. This aligns with results of study by McAfee, Brynjolfsson, Davenport, Patil, and Barton (2012), that shows firms using big-data and AI in practice boost the value of their intellectual capital and help the supply chain keep stable during changes in the environment (Ahmed, Sumbal, Lee, & Tsui, 2025). It also helps businesses coordinate with supply chain partners, making sure knowledge assets are shared, so teams can respond well to disruptions (Christopher & Peck, 2004). Because of DDC, IC improves SCR by heavily investing in technologies that help risk management efforts and quick adaptation (Lu, Chiang, Wu, & Xu, 2025).

When organizations embed DDC into their operations, the knowledge assets embedded in IC are more effectively mobilized to anticipate, absorb, and adapt to disruptions (Gao, Wang, Feng, & Jiang, 2025). Although direct empirical studies specifically testing DDC as a moderator between IC and SCR are still limited, conceptual frameworks and adjacent studies

(Kong & Feng, 2025; X. Liu et al., 2025) support the proposition that DDC strengthens the IC–SCR linkage by enabling better utilization of intellectual resources through data-informed strategies. Therefore, it can be hypothesized as;

H_3: Data driven culture moderates the relation between Intellectual Capital and Supply Chain Resilience.

Many organizations now pay special attention to SCR to respond to disruptions and continue their activities. Collaboration, sharing of important information and working together increase how resilient a company can be However, the success of using SCI relies in part on a firm's data-driven culture which makes it easier to base decisions and predictions on data. By having integration of information, operations and relationships, SCI supports resilience by helping the organization become more observant, agile and responsive. The results of some recent studies suggest that having a high SCI allows firms to bounce back more effectively from disturbances (Zamani, Smyth, Gupta, & Dennehy, 2023). Effective DDC allows organizations to use BDA to make better decisions, forecast situations and manage risk (Ivanov, 2023). Studies show that well-implemented DDC in a firm helps enhance SCI and ensures better resilience (Jiang, Feng, & Huang, 2024). Specifically, DDC moderates the association between SCI and SCR by enhancing real-time data utilization for proactive risk mitigation (Rane, Choudhary, & Rane, 2024), facilitating machine learning applications to predict supply chain uncertainties (Y. Liu et al., 2022) and strengthening collaborative decision-making through data transparency (Adewusi et al., 2024).

Data-driven culture can significantly moderate the relationship between supply chain integration and supply chain resilience. The positive effects of SCI on SCR are amplified in firm that possess a strong DDC characterized by data-informed decision-making and analytics capability (Jiang et al., 2024). Their configurational analysis revealed that DDC enhances the effectiveness of information, operational, and relational integration, enabling firms to better anticipate and respond to disruptions. Similarly, DDC strengthens the link between big data analytics and green supply chain integration, indirectly supporting the argument that DDC facilitates the translation of integrated supply chain processes into resilient outcomes (Y. Liu et al., 2022). Hence it can be hypothesized that:

H_4: Data Driven culture moderates the relation between Supply Chain Integration and Supply Chain Resilience.

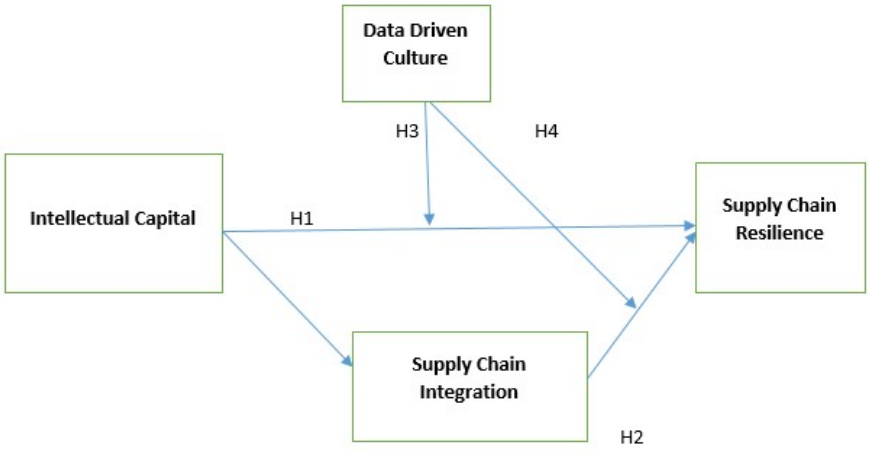

Figure 1. Theoretical Framework

3. Research Methodology

3.1 Sample and Data collection

This study employs a quantitative research design to examine the impact of intellectual capital on SCR, incorporating SCI as a mediator and data-driven culture as a moderator. Sampling methods is broadly categorized as probability sampling and non-probability sampling (Saunders, Lewis, & Thornhill, 2003). The current study utilizes non-probability sampling, specifically convenience sampling, due to its feasibility and accessibility for data collection (Etikan, Musa, & Alkassim, 2016). Convenience sampling is widely adopted in exploratory studies where respondents are selected based on their availability and willingness to participate, making it an effective approach for field research in organizational settings. Given the objective nature of the inquiry, a survey-based approach was employed to collect empirical data from the telecommunication sector in Pakistan. Structured questionnaires were disseminated via Google Forms to respondents employed in the telecommunication sector in Rawalpindi and Islamabad to collect primary data. The structured questionnaire ensures uniformity in responses and aids in quantitative analysis (Etikan et al., 2016). Participation was voluntary and respondents were informed of the research purpose and their rights through an informed consent statement at the beginning of the survey. The study complied with ethical standards for research. Participants were initially approached via professional networks, LinkedIn, industry forums, and academic contacts. Personalized invitation emails or messages explained the study's purpose, ensured confidentiality, and emphasized voluntary participation. A follow-up reminder was sent after two weeks to increase the response rate. To minimize nonresponse bias and encourage participation, the survey was kept concise and user-friendly, with pre-tested items and an estimated completion time of 10–15 minutes.

Table 1. Measurement Scale

Constructs		Items	Reference
Intellectual Capital	RC	4 items	Choudhury (2010)
	SC	4 items	
	HC	5 items	
Data-Driven Culture	DDC	4 items	Yu, Liu, Zhao, and Song (2021)
Supply Chain Resilience	SCR	4 items	(Piprani, Mohezar, & Jaafar, 2020)
Supply Chain Integration	SI	5 items	(Piprani et al., 2020)
	II	5 items	
	CI	5 items	

Out of approximately 320 individuals contacted, 239 provided complete and valid responses, yielding a **response rate of 74.7%**, which is considered robust for online survey research in organizational contexts. The questionnaire utilized five point Likert scale where "5= Strongly Agree, 4= Agree, 3= Neutral, 2= Disagree, 1= Strongly Disagree". Table 1 provide the sources of the constructs along with the items. The scales were adopted from previous studies. The number of items and sources are given in the Table 1. The sample items for IC include "We are skilled at collaborating with each other to diagnose and solve problems" (RC), "Our organization uses patents and licenses as a way to store knowledge" (SC), "Our organization uses patents and licenses as a way to store knowledge" (HC). The sample items for SCR is "Our firm's supply chain has the ability to maintain control over structure and function during disruptions". The sample item for DDC is "We continuously assess and improve the business

rules in response to insights extracted from data". The sample items for SC Integration include "We have a high degree of strategic partnership with our key suppliers" (SI), "We share our service plans with our major customers" (CI) and "Internal management communicates frequently about goals and priorities" (II).

3.2. Data Analysis and Profile of respondents

The sample consists of 59.8% males and 40.2% females, indicating a male-dominated workforce but with a notable female representation. This aligns with trends in many industries where leadership and technical roles tend to have a higher proportion of male professionals, though representation is gradually shifting. The majority of respondents (61.5%) are younger than 30 years, followed by 33.9% aged 30-35 years, and only 4.6% above 40 years.

Table 2. Respondents Profile

Category	Sub-category	Frequency	Percentage
Gender	Male	143	59.8
	Female	96	40.2
Age	Less than 30 years	147	61.5
	30-35 years	81	33.9
	Above 40 years	11	4.6
Experience	< 5 years	123	51.5
	5-10 years	57	23.8
	> 10 years	59	24.7
Designation	Senior Manager	28	11.7
	Middle Level Manager	110	46.0
	Support Staff	64	26.8
	Others	37	15.5

This suggests that the workforce is predominantly young, likely due to the dynamic and tech-driven nature of the telecommunications sector, which often attracts younger professionals. 51.5% have less than 5 years of experience, with 23.8% between 5-10 years and 24.7% over 10 years. This distribution indicates that the workforce is relatively new, with a smaller segment possessing extensive industry experience. The largest proportion of respondents (46.0%) are middle-level managers, followed by 26.8% in support roles, 11.7% in senior management, and 15.5% classified as 'Others'. The significant representation of middle management suggests that decision-making and strategic execution responsibilities lie primarily at this level.

3.3 Descriptive Statistics

The descriptive statistics suggest an overall favorable response across constructs, with all mean values except for Human Capital (HC = 3.31) clustered around or above 4.0, indicating that respondents largely agreed with the statements provided. The relatively low standard deviations (ranging from 0.44 to 0.58) indicate tight variability, implying consistent patterns in responses across participants. Skewness values remain within the commonly accepted threshold of ±1, reflecting approximate normality and symmetry in data distribution (George & Mallery, 2024). Although constructs like II (-0.739) and HC (-0.636) show moderate negative skewness, they do not exceed critical values for concern. Kurtosis also lies within the ±2 range, except SCR (0.803) and II (0.883), which are slightly leptokurtic but still acceptable for parametric tests (Hair, Sarstedt, & Ringle, 2019). These distributional characteristics support the suitability of the dataset.

Table 3. Descriptive Statistics

Constructs	Minimum	Maximum	Mean	SD	Skewness	Kurtosis
RC	2.80	5.00	4.104	0.495	-0.510	0.138
SC	2.25	5.00	4.152	0.577	-0.342	-0.174
HC	2.00	4.00	3.307	0.457	-0.636	0.056
DDC	2.80	5.00	4.077	0.501	-0.077	-0.426
SCR	1.50	5.00	4.084	0.562	-0.136	0.803
II	2.20	5.00	4.184	0.565	-0.739	0.883
CI	2.40	5.00	4.093	0.503	-0.048	0.203
SI	3.00	5.00	3.983	0.442	0.027	-0.030

Note: Relational Capital (RC); Structural Capital (SC); Human Capital (HC); Supply Chain Resilience (SCR); Internal Integration (II); Customer Integration (CI); Supplier Integration (SI); Standard Deviation (SD).

3.4. Reliability Analysis

Cronbach's Alpha is the measure of the reliability and internal consistency of a construct. Value above 0.7 are considered acceptable, and all constructs exceed this threshold in Table 4, indicating that the items within each construct are consistent and reliable.

Table 4. Reliability

Construct	Cronbach Alpha
Intellectual Capital	0.833
Supply Chain Resilience	0.735
Supply Chain Integration	0.826
Data Driven Culture	0.764

3.5 Correlation Analysis

This correlation matrix provides insights into the relationships between Intellectual Capital (IC), Supply Chain Resilience (SCR), Data-Driven Culture (DDC), and Supply Chain Integration (SCI) at significance level of 0.01. A moderate positive correlation between IC and SCR suggests that higher levels of intellectual capital are associated with stronger supply chain resilience.

Table 5. Correlation

Correlations				
	IC	**SCR**	**DDC**	**SCI**
IC	1			
SCR	0.507**	1		
DDC	0.359**	0.327**	1	
SCI	0.652**	0.420**	0.483**	1

IC=Intellectual Capital, CSR=Supply Chain Resilience, SCI=Supply Chain Integration, DDC=Data Driven Culture
Note: **. Correlation is significant at the 0.01 level (2-tailed).

The positive correlation IC and DDC indicates that organizations with strong intellectual capital also tend to embrace a data-driven culture. The strongest correlation, between IC and SCI demonstrates a highly positive association between Intellectual Capital and Supply Chain Integration. A moderate positive correlation suggests that greater supply chain integration enhances resilience. The positive correlation suggests that organizations with high supply chain integration are likely to operate with a strong data-driven culture. The weakest correlation

among the significant relationships is between DDC and SCR, indicating that while data-driven culture contributes to resilience, its impact may be indirect or influenced by other moderating variables.

3.6. Moderation Analysis

The model shows a moderate relationship between predictors and the outcome (R = 0.551), with about 30.4% of the variance explained ($R^2 = 0.304$). The F-statistic (34.253) indicates the model is statistically significant and performs better than a model with no predictors. The positive and significant coefficient (0.430, $p < .001$) confirms that Intellectual Capital enhances Supply Chain Resilience. Organizations leveraging intellectual assets demonstrate greater adaptability and robustness in their supply chains.

Table 6. Moderating Role of DDC between IC and SCR

	R	R^2	MSE	F		
	0.551	0.304	0.222	34.253		
Predictor	**B**	**SE**	**T**	**P**	**LLCI**	**ULCI**
IC	0.430	0.089	4.61	.000	0.236	0.589
DDC	0.576	0.073	7.66	.000	0.414	0.701
IC × DDC->SCR	0.774	0.106	7.27	.000	0.565	0.985

Note: Standard Error (SE); Lower Limit Confidence Interval (LLCI); Upper Limit Confidence Interval (ULCI)

A strong Data-Driven Culture (0.576, $p < .001$) independently contributes to Supply Chain Resilience, emphasizing the role of data driven culture and informed decision-making in maintaining operational stability. The interaction term (0.774, $p < .001$) suggests that Data-Driven Culture strengthens the positive effect of Intellectual Capital on Supply Chain Resilience. Organizations with high intellectual capital exhibit greater resilience, particularly when data-driven decision-making principles are embedded in their operational culture.

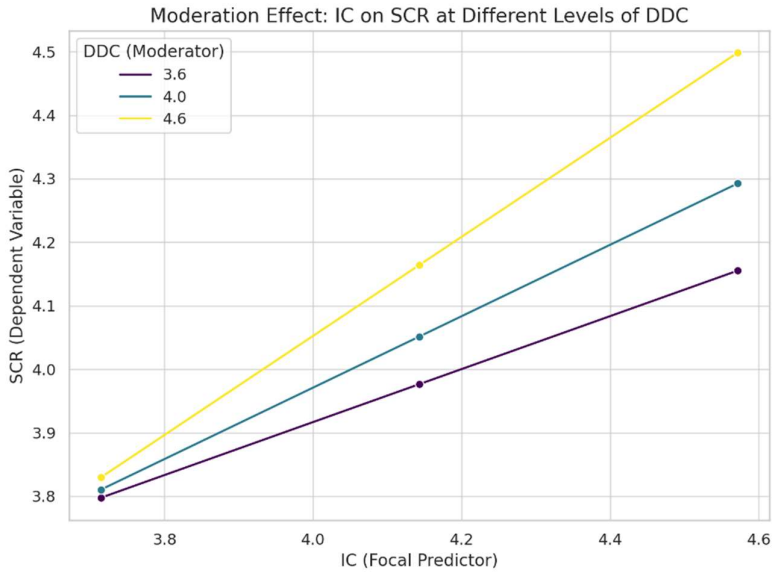

Figure 2. Moderation Effect of IC on SCR

The graph illustrates the moderating effect of Data-Driven Culture on the relationship between Intellectual Capital (IC) and Supply Chain Resilience (SCR). The three lines represent different levels of DDC. At lower levels of DDC, the relationship between IC and SCR is relatively flat.

This suggests that even if a firm has high intellectual capital, its impact on resilience is limited when data-driven practices are weak. The slope becomes steeper, indicating that with moderate DDC, intellectual capital begins to translate more effectively into resilient outcomes. This line shows the steepest slope, meaning firms with both high IC and strong data-driven culture see the greatest improvement in SCR.

Table 6. Moderating Role of DDC between SCI and SCR

	R	R^2	MSE	F		
	0.462	0.213	0.251	21.283		
Predictor	**β**	**SE**	**T**	**p**	**LLCI**	**ULCI**
IC	0.498	0.124	1.33	0.004	0.331	0.635
DDC	-0.587	0.120	-1.88	0.051	0.065	0.126
SCI × DDC->SCR	0.291	0.129	2.25	0.025	0.036	0.546

Note: Standard Error (SE); Lower Limit Confidence Interval (LLCI); Upper Limit Confidence Interval (ULCI).

The regression output indicates that the model demonstrates a moderate level of explanatory power, with R = 0.462, suggesting a reasonable positive correlation between predictors and the dependent variable. Approximately 21.4% of the variance in the outcome is explained by the predictors ($R^2 = 0.213$), which reflects a modest but meaningful effect size (Cohen, 1988). The MSE of 0.2517 indicates acceptable average error in prediction, given typical behavioral data variability. Finally, the F-statistic of 21.283 confirms that the model is statistically significant. The direct effect of Supply Chain Integration on Supply Chain Resilience is not statistically significant (p = 0.004), indicating that, supply chain integration alone does have a strong predictive impact on resilience. The main effect of Data-Driven Culture (DDC) on SCR is nearly significant at p = 0.0510, suggesting that while DDC does influence resilience, it is not strongly significant at the traditional threshold of 0.05. The interaction term is significant (p = 0.025), confirming that Data-Driven Culture moderates the relationship between SCI and SCR. The positive coefficient (0.291) suggests that as DDC strengthens, the relationship between SC Integration and SCR becomes positive, meaning that in environments where data-driven decision-making is highly emphasized, Supply Chain Integration contributes more effectively to resilience.

3.7. Mediation Analysis

Table 8. Mediating Role of SCI

	R	R^2	MSE	F		
	0.651	0.424	0.098	175.047		
Predictor	**β**	**SE**	**t**	**p**	**LLCI**	**ULCI**
IC	0.505	0.091	5.52	.000	0.325	0.686
SCI	0.212	0.099	2.13	.034	0.016	0.409
Direct effect of X on Y						
	β	**SE**	**t**	**p**	**LLCI**	**ULCI**
	0.505	0.091	5.527	.000	0.325	0.686
Indirect effect(s) of X on Y:						
	β	**Boot SE**	**Boot LLCI**	**Boot ULCI**		
	0.1271	0.068	-0.001	0.265		

The model exhibits a strong predictive relationship, with R = 0.651, indicating a substantial positive association between the predictors and the outcome. Approximately 42.5% of the variance in the dependent variable is explained ($R^2 = 0.424$), which represents a large effect size (Cohen, 1988). The MSE of 0.098 suggests relatively low average prediction error, which further supports the model's accuracy. An F-statistic of 175.05 signals that the overall regression model is statistically significant, meaning the predictors collectively offer a robust explanation of the outcome. The direct effect of Intellectual Capital (IC) on SCR is statistically significant ($p < 0.001$). The positive coefficient (0.505) suggests that higher levels of intellectual capital lead to stronger supply chain resilience, reinforcing the importance of human, structural, and relational capital in supply chain adaptability. Supply Chain Integration (SCI) significantly predicts Supply Chain Resilience (SCR) ($p = 0.034$).

Table 9. Results of Hypothesis

Hypothesis	Decision
H_1: Intellectual Capital has a significant impact on Supply Chain Resilience.	Accepted
H_2: Supply Chain integration mediates the relationship between Intellectual Capital and Supply Chain Resilience.	Rejected
H_3: Data driven culture moderates the relation between Intellectual Capital and Supply Chain Resilience.	Accepted
H_4: Data Driven culture moderates the relation between Supply Chain Integration and Supply Chain Resilience.	Accepted

The positive coefficient (0.212) suggests that higher SCI leads to greater supply chain resilience, indicating that collaboration, information sharing, and process alignment within the supply chain enhance resilience. The indirect effect of IC on SCR through SCI is 0.127, with a standard error of 0.068. The lower bound (Boot LLCI) is -0.001, and the upper bound (Boot ULCI) is 0.265. Since the bootstrap includes zero, the mediation effect is not statistically significant, meaning SCI does not fully mediate the IC-SCR relationship. However, the indirect effect size suggests that SCI mediates the relationship partially, implying that while intellectual capital directly enhances SCR, integration plays a supplementary role in strengthening this effect.

5. Discussion

The results of this study support previous studies highlighting the significance of IC in augmenting Supply Chain Resilience. The notable positive correlation between intellectual capital (IC) and supply chain resilience (SCR) indicates that companies utilizing human, relational, and structural capital have enhanced adaptability and strength in their supply chains. Yu et al. (2023) explored the mediation and interaction effects of IC on supply chain resilience, confirming that knowledge assets contribute to resilience through integration and learning mechanisms. Mubarik et al. (2022) discovered that a higher level of intellectual capital ensures better supply chain resilience, especially when structural capital is sufficiently strong. The findings exhibit that intellectual capital provides an advantage by helping firms manage surprises and maintain stability. Moreover, the effect of DDC on improving the relationship between SCI and SCR supports earlier findings showing that data-driven decisions improve a supply chain's capability to respond to new situations (Mubarik et al., 2022). The study shows that linking data analytics and knowledge management to supply chains increases a company's adaptability and effectiveness when facing market challenges.

The absence of Supply Chain Integration as a mediator suggests that Intellectual Capital can directly affect Supply Chain Resilience. This divergence from some prior studies may be rooted in sector-specific dynamics. For instance, the telecom industry in Pakistan is characterized by hierarchical structures and tightly regulated processes, which may limit the agility and

permeability needed for integration mechanisms to function effectively as mediators. In line with (Yu et al., 2023), it appears that resilience can be achieved directly through intellectual capital**,** particularly when adaptive routines and autonomous decision-making are emphasized over process integration. Additionally, Muafi and Sulistio (2022) point to digital infrastructure and technological readiness as boundary conditions for SCI's mediating role, capabilities that may still be underdeveloped across parts of Pakistan's telecom landscape. The lack of mediation may also reflect the maturity level of integration practices, where merely having integrated systems or collaborations is insufficient unless paired with adaptive intent and learning orientation.

Similarly, Mubarik et al. (2021) claim that businesses rich in intellectual capital can react well to disruptions on their own, since using human and organization-specific assets helps them bounce back effectively, without the need for increased integration. Christopher and Peck (2004) add that, unlike some previous theories, resilience might arise from employing strategic solutions with knowledge, not from integrating it.

5.1 Theoretical Contributions

This study contributes to the supply chain management literature by integrating intellectual capital with resilience frameworks, reinforcing the relevance of Dynamic Capability Theory in complex supply chain environments. By empirically validating the impact of IC on supply chain resilience. The study underscores that knowledge-based resources particularly human, structural, and relational capital are foundational enablers of resilience capabilities. The identification of data-driven culture as a significant moderator further extends theoretical understanding of how cultural enablers influence the efficacy of intangible assets. These findings offer a nuanced perspective on how organizational culture interacts with strategic resources to shape supply chain outcomes, encouraging future research to integrate DDC as a boundary condition in knowledge-based and dynamic capability models.

5.2 Practical Contributions

From a managerial perspective, the results emphasize the need for organizations particularly in data-intensive, disruption-prone sectors like telecommunications to invest in intellectual capital development. Supply chain managers should focus on nurturing employee expertise, institutionalizing organizational knowledge, and reinforcing strategic partnerships to ensure continuity during crises. The findings also highlight the role of data officers and IT leaders in cultivating a data-driven culture that complements integration efforts and strengthens the firm's ability to absorb shocks. Organizations should align their technology adoption strategies with supply chain objectives, leveraging AI-driven insights and data analytics to convert intellectual assets into actionable resilience outcomes. These insights are especially valuable for practitioners operating in emerging economies, where agility and knowledge utilization can help offset infrastructure and regulatory constraints.

5.3 Limitations and Future Research Direction

Although this study provides meaningful insights into the interplay between intellectual capital, supply chain integration, data-driven culture, and supply chain resilience, several limitations must be acknowledged. First, the research relied on a cross-sectional, survey-based design, which restricts the ability to establish causality or observe dynamic changes over time. Future research could adopt longitudinal designs to track how intellectual capital and resilience capabilities evolve, especially in response to external shocks or strategic transformations. Second, the use of convenience sampling from telecom firms in Rawalpindi and Islamabad introduces selection bias, potentially limiting the generalizability of findings. Researchers are encouraged to employ probability based sampling techniques or incorporate multi-regional and multi-sectoral data to enhance representativeness. Including comparisons between industries

or countries could also provide a broader understanding of contextual drivers of supply chain resilience. Third, the data collection method structured self-report surveys poses risks of common method bias and social desirability bias. These can be mitigated in future studies through triangulation. Fourth, although this study explored supply chain integration as a mediator, the non-significant mediation effect suggests alternative pathways should be investigated. Future studies may consider variables such as organizational agility, digital capability, or absorptive capacity as potential mediators or moderators in the relationship between intellectual capital and resilience. Finally, control variables such as firm size, age, sub-sector, or ownership structure were not included. Incorporating these factors could enhance explanatory power and help isolate the effects of core constructs. By addressing these methodological and contextual limitations, future research can build deeper, more generalizable insights and further develop resilient supply chain frameworks grounded in intellectual capital and data-driven cultures.

5.4 Conclusion

This research investigated the influence of Intellectual Capital (IC) on Supply Chain Resilience (SCR), with Supply Chain Integration (SCI) serving as a mediator and Data-Driven Culture (DDC) as a moderator. IC significantly enhances SCR affirming that intellectual assets contribute to resilient supply chains. SCI positively influences, reinforcing the role of collaborative and integrated supply chain practices in strengthening resilience. SCI acts as a partial mediator between IC and SCR, but the indirect effect was not statistically significant suggesting that while integration facilitates resilience, IC remains the dominant driver. DDC has a moderating role between SCI and SCR, indicating that a strong data-driven culture amplifies the impact of supply chain integration on resilience.

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