TheImpactofRelational,Technological,andCommunicationDiversityonSupplyChain Resilience: The Mediating Role of Collaborative Cyber Risk Management

Name: Sameera SulemanEnrollmentNumber:01-322232-025

Program:MBASupplyChain

Major No: S6

SupervisorName:DrAliImtiaz

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Abstract

The objective of this research is to analyze the effect of Relational, Technological and Communication Diversity on SCR with mediating role of CCRM in Pakistan introduced by MNCs. The present paper first looks at the consequences of this diversity in a supply chain perspective and then accounts for amplifying exposure to cyber-attack. This study is developed with a quantitative design, using cross-sectional survey as MNC managers have responded to standardized Likert scale questionnaire. The relationships were tested with PLS-SEM to investigatethedata.TheresultsindicatethatCCRMhasahighlypositiveimpactonSCR,andthe pathcoefficientis0.701(p<0.001),whichconfirmsthatCCRMisapowerfulfactorforresilience identification. In addition, Technological Diversity was established as the most significant predictor for CCRM while Relational and Communication Diversity could predict CCRM too. CCRM emerged as a mediator, for transforming varied inputs into resilience.This research adds to the literature by combining Resource- Based View (RBV) and Dynamic Capabilities Theory (DCT) and offers empirical verification on the role of CCRM for developing resilient supply chains. Practical implications are drawn for MNCs to establish CCRM methodology and cross-level integration practices to improve resilience against cyber disruptions.

Keywords: Supply Chain Resilience (SCR), Cyber Chain Risk Management (CCRM), Technological Diversity, Relational Diversity, Communication Diversity, Multinational Corporations (MNCs), Pakistan

Abbreviations

IVs–IndependentVariables
CCRM–CollaborativeCyberRiskManagement MNCs
– Multinational Corporations
CD–CommunicationDiversity
PLS-SEM–PartialLeastSquaresStructuralEquationModeling CFA –
Confirmatory Factor Analysis
RBV–Resource-BasedView RD
– Relational Diversity
CI – Confidence Interval
RO–ResearchObjective
CPEC–China–PakistanEconomicCorridor RQ
– Research Question
COVID-19–CoronavirusDisease2019 SC
– Supply Chain
CRM–CustomerRelationshipManagement SCI
– Supply Chain Integration
CSCRM–CyberSupplyChainRiskManagement SCM –
Supply Chain Management
DC – Dynamic Capabilities
SCR–SupplyChainResilience
DCT– Dynamic CapabilitiesTheory
SEM–StructuralEquationModeling
DV – Dependent Variable
SPSS–StatisticalPackagefortheSocialSciences ERM –
Enterprise Risk Management
TD–TechnologicalDiversity
ERP–EnterpriseResourcePlanning
USD – United States Dollar f^2 –
Effect Size (F-Square)
HTMT–Heterotrait–Monotrait Ratio
ICT–InformationandCommunication

TableofContents

ListofTables

Listof Figures

CHAPTER 1Introduction

1.1 ResearchArea

Both manufacturing and services sector have started to source from multiple countries to gain a competitive edge through efficient supply chain strategies (Folke, 2006). Reasons for Production offactorssuchastechnologicalinnovation,reducingproductlifecycles,reductionofproductprice and total cost of usage, reducing the number of suppliers established and strategic relations (Creazza et al., 2022).

As companies extend their supply chain operations, they run into problems and unexpected occurrences. Supply chains are subject to a variety of disruptions, delays in shipment (Gomez et al., 2021), stockouts (Talluri et al., 2013), quality problems, information breakdowns, machine breakdowns, natural disasters as floods and earthquakes or man-made disasters such as terrorism among all other factors that demonstrate the turbulence affecting supply chain (Creazza et al., 2022a). The risk entities within companies have significantly increased due to growth, explosive expansion in areas of operation and new technology (Ritter & Pedersen, 2020).

Today, the organization of firms operates across national borders and is orchestrated within networks that include various stakeholders who have their specific cultural, technological, and managerial practices (Palit et al., 2022). This interdependence brings efficiencies and innovation but now also creates some dependencies when shocks come up. In these settings, diversity in supply chains such as structural, technological or communicative becomes not only a strategic asset but also a potential source of risk (Shokouhyar et al., 2024).

Relationship diversity describes the diversity in cultural, institutional and trust relationships betweensupplychainpartners.Whenproperlymanaged,itencouragesinnovation,flexibilityand adaptability by meeting disparate viewpoints as well as problem–solving perspectives (Sirmon et al., 2011). Differently, relational differences that are left unmanaged can result in conflicts, coordination problems and waste, especially where trust is absent or no collaboration mechanism has been established (Falcone et al., 2024).

Global business today has witnessed a dramatic change in the digital era, and hits enterprises to adapt and succeed in a challenging marketplace (Creazza et al., 2022; Yin &Ran, 2022)**.** his transformationhasitsrootsintheconceptofdigitaltransformation,whichreferstotheinfusionof advanceddigitaltechnologyintoallareasofabusinesswiththeaimofimprovingbothinnovation andoperatingefficiency(Gomezetal.,2021;Warner&Wäger,2019).Thefocusontechnologies has been growing in importance with the emergence of Industry 4.0, digital platforms, and sophisticated IT infrastructures (Talluri et al., 2013). Certainly, on the one hand, various technological systems could increase flexibility and new solutions to make supply chains more robust (Falcone et al., 2024b). On the other hand, diversity of IT tools and platform may lead to interoperability issues, integration problems etc. Consequently, firms must weigh the benefits of diversity against system mismatches and cyber risks (Awan & Ali, 2022). Digitalized manufacturingisanimportantwayofcompanies'transformation(Lietal.,2025).Thedigitization oforganizationsrealizestheextensiveapplicationandimplementationofall-roundandtailoredto-needsdigitalcapabilities,thusfacilitatingthepredictionofrisksintime,reducinguncertainties,as well as enhancing risk management. As a result, implementing digital transformation is an important approach for firms to deal with supply chain risks and build up the resilience of supply chain(Daietal.,2025).Uptothepresent,largepartsoftheliteratureindigitaltransformationonly draw on unidimensional interpretations explaining why some firms increase their performance while implementing such initiatives while others keep lagging (Khurana et al., 2022).

Theresourceorchestrationtheoryarguesthatacompanyneedstohavecertainresourcesbut,more importantly, manage and configure them in an effective way. Hence, in terms of resource orchestration(Nwankpaetal.,2022),theyclassifydigitaltransformationofenterprisesintodigital transformation breadth and digital transformation depth; digital transformation breadth is how wideorhowmanydifferenttypesofthedigitaltechnologiesthatafirmhasadopted,whiledigital transformationdepthreferstotheextentorlevelatwhichthefirmdeploysitsadoptedtechnologies. Organizations that can pursue deeper digitization of their activities can make greater strides in improving practices across the organization.

Communicationdiversityisparticularlyessentialinatimeofgloballydispersedsupplychainsand polylingual, poly multicultural most groups. Though diversity allows firms to enter in numerous markets, it delivers barriers at coordination and decision-making front (Khan et al., 2024). Misunderstanding, miscommunication and delay in sharing information cause rise of risk especially quickly response required for smooth running the operation. This in turn enables a framework for understanding vulnerability and resilience within the supply chain (Qazi et al., 2024).

Cyberriskisprimarytechnicalaspectandithappensindiversity.Ransomwareanddatabreaches, as well as system downtime, these are examples of the sort of risks that come with digital supply chain (Kleist, 2021). The COVID-19 crisis revealed even more weak spots as related logistics, workforce and IT disruptions played out across businesses. In this context, the co-operation of cyber risk management has therefore become necessary Supply chain integration (SCI) has been considered an important approach to risk management and to dealing with uncertainty, but there are still questions about the proper implementation of SCI such as it increases system resilience (Folke, 2006). There has been research on the relationship between supply chain risk and supply chain integration, this nexus is not clear yet in its early stages, mainly about which risks can be reduced through integration and what form of the process could effectively deal with them. Qazi et al. (2024) indicated that internal management failures result in risk exposures. Consequently, internal integration may resolve the issue. Nwankpa et al. (2022) found that both external and internalrisksadverselyaffectafirm'sperformance;consequently,integratedmeasuresaddressing both types of risks should be implemented to prevent disruptions. The major risks are due to changes in demand and supply; however, these risks can be countered by practices and managing operations within and outside the company (Baiyere et al., 2020).

This is especially important in emerging economies like Pakistan MNCs that are facing infrastructural,andcyberthreatschallengesandrequireculturallydiversepartnerstoexaminethe interplay between relational, technological, and communicative diversity and collaborative cyber risk management to strengthen SCR. This paper contributes to this literature by exploring these relationshipsinaPakistancontextbaseduponbroaderglobalsupplychaindiscussions(Abdullahi et al., 2025).

1.2 Context:Supply Chainsin Pakistan

The supply chains of Pakistan are integrating with global and regional production systems as the manufacturing industry, logistics, and IT services are rapidly increasing. Therefore, the role of resilient supply chains in textiles, food processing and pharmaceuticals is increasingly dependent on MNCs that are dynamic and have market acceptance (Wang & Han, 2024). However, lack of infrastructure, inefficient communication networks and reliance on imported technologies offer huge problems to country’s SC (Huang et al., 2023). Technology is growing with emergence of ecommerce and digital platforms however, cyber risks such as IT system failure, ransomware attacks and data breaches are increasing as well (C.Yang et al., 2025).

Examiningsupplychaindiversityandresilienceincontextof Pakistanisimportantbecauseoftwo reasons. One as a developing economy it is enhancing its industrial foundation, and secondly the China-Pakistan Economic Corridor (CPEC) that has a critical role in global supply chain. The analysis of diversity and collaborative cyber risk management offers insights to both local enterprises and the resilience of global markets.

1.3 ProblemDomain

The problem domain of this study involves an emerging context of worldwide SCR, including challenges that arise in an increasingly globalized society due to globalization and digital transformation.Withtheworld'ssupplychainscrossingmultipleterritoriesandsectors,businesses areexposedtoavarietyofoperationalandcyberrisksuchasdelaysinshipping(naturaldisasters), cyber risk or failure systems. These disruptions are particularly enhanced by the digitization of business processes, which integrates things like cloud computing, ERP systems and blockchain technologies. These developments enhance efficiency and decision making but also come with problems such as interoperability and increased susceptibility to cyber-attacks.

Relational variety of supply chains is growing, in both cultural norms, trust levels and habit of collaborating by their partners. Furthermore, technological heterogeneity, including different IT systems and digital tools, further hampers integration and coordination work.Yet, one important dimension poorly understood in extant work is communication diversity: variation among groups of individuals in language, communicative routines, and modes of sharing information. Prompt responsetodisruptionsiscrucialforglobalsupplychains,whichrequiregoodcommunicationand coordination to perform effectively, but language and culture impedes efficient coordination frequently.

In markets like Pakistan, these issues are compounded. Enterprises and MNCs in Pakistan are challenged by infrastructure constraints, cybersecurity threats, and asymmetric levels of digital readiness throughout their supply chains. Yet, as these supply networks have become more complex, not much is known about how information diversity (emphasis on relational and technological)andcommunicationdiversityjointlyaffectsupplychainresilienceinsuchcontexts.

This article addresses this gap by studying the effects of these diversities, along with CollaborativeCyber Risk Management (CCRM), on supply chain resiliency in Pakistan.

Global SCs are operating in uncertainty where there is threat of cyber-attacks and operational disruptions. Companies must rely on interconnection to minimize the threats of data breaches, ransomware attacks and systems failures in digital networks (Schwertner, 2017). These vulnerabilities were compounded by the COVID-19 pandemic, which caused logistic delays, productionflowfaultsanddigitalizationwithrelatedcybersecurity.Thisway,itispossibletosay that the increasing level of competitiveness and diverse problems faced by companies have led, inevitably, various business chains to several types of disruptions (Baiyere et al., 2020).

Asystematic intervention is required to address the transition that turns company from instability towards stability (Creazza et al., 2022). he capability development of organizations to respond to such disruptive events is key for practicing professionals. The capacity for the organization to managedisruptionandmaintainnormaloperationsiscalledSustainedCapabilityResearch(SCR). TheeffectsofSCRonfinancialperformancearestillcontroversial,despiteagreatdealofresearch performedonthetopic(Warner&Wäger,2019).Theresearchersmaintainthattheimplementation of supply chain resilience serves as a buffer against surplus capacity, hence questioning the association;accessopenthingssuchasdeployingdiversesourcesofsuppliescreateshighlogistics cost,involvementinnosupplyleadstoincreasedcapitalexpenditureanduse(Baiyereetal.,2020; Nwankpa et al., 2022; Wang & Han, 2024).

Research It has made some progress on examining the impacts of heterogeneities in relational diversitiesinculturalnorms,trust-buildingdevices,andmodesofcollaborationuponsupplychain outcomes.Similarly,literaturesontechnologydiversityhavealsohighlightedthebenefitsofdigital integration as well as the challenges from interoperability issues (Khurana et al., 2022).Yet, the third essential direction, that of communication diversity, arguably remains most underexplored. Language, confusion and lack of communication are significant factors impeding coordination, decision-makingandcontrolmechanismenforcementinbothglobalandmulticountysupplychain, exacerbatedbytheextentofpoorcommunicationonhowtomanagecyberrisk.Althoughofgreat importance in practise, communication diversity is not well studied in supply chain resiliency literature (Li et al., 2025).

1.4 ProblemStatement

Globalsupplychainsareincreasinglyexposedtocompoundedoperationalandcyberdisruptions due to rapid digitalization, inter-firm interdependence, and heterogeneous technological infrastructures (Cao et al., 2024; Shokouhyar et al., 2024). Recent studies highlight that cyberattacks,ransomwareincidents,andsysteminteroperabilityfailuresnowrepresentsomeof the most critical threats to supply chain continuity and resilience, particularly in digitally integrated networks (Rahman et al., 2025; Yang et al., 2024).

Although prior research has examined relational and technological diversity as antecedents of supply chain resilience, empirical findings remain fragmented and context-dependent, with limited consensus on how these diversity dimensions can be transformed into resilienceenhancing capabilities (Falcone et al., 2024; Qazi et al., 2024). Moreover, communication diversity, referring to variations in language, clarity, and information-sharing routines—has received insufficient empirical attention, despite recent evidence suggesting that communicationfailuressignificantlyamplifycyberandoperationalrisksinglobalsupplychains (Shishodia et al., 2023; Rahman et al., 2025).

Importantly,whilecollaborativecyberriskmanagement(CCRM)hasbeenincreasinglyproposed as a strategic response to cyber-enabled supply chain disruptions, its role as a mediating mechanism between supply chain diversity and resilience remains underexplored, particularly in emergingeconomiessuchasPakistan,whereinfrastructuralconstraintsandunevencybersecurity maturity persist (Abdullahi et al., 2025; Palit et al., 2022). This lack of empirical evidence restricts managers’ability to design coordinated resilience strategies that effectively convert diversity-induced complexity into adaptive strength.

1.5 ResearchQuestions

RQ1: Howdoesrelationaldiversityinfluencesupplychainresilienceinmultinationalorganizations in Pakistan?

RQ2: Whatimpactdoestechnologicaldiversityhaveonsupplychainresilienceinpakistan?

RQ3: Howdoescommunicationdiversityaffectsupplychainresilienceinmultinational organizations operating in Pakistan?

RQ4: Doescollaborativecyberriskmanagement(CCRM)mediatetherelationshipbetween relational, technological, and communication diversity and supply chain resilience?

1.6 ResearchObjectives

RO1: Toexaminetheeffectofrelationaldiversityonsupplychainresilienceinmultinational organizations operating in Pakistan.

RO2: Toanalyzetheimpactoftechnologicaldiversityonsupplychainresilienceinthecontextof Pakistan.

RO3: Toevaluatetheroleofcommunicationdiversityinenhancingsupplychainresilienceamong multinational organizations.

RO4: To investigate the mediating role of collaborative cyber risk management (CCRM) in the relationship between supply chain diversity dimensions and supply chain resilience.

1.7 ResearchGap

According to literature review and the identified research gaps, the latter can be classified at theoretical, contextual level and practice based. These are clearly summarized below.

TheoreticalGap

Most existing research has been centered on relational and technological diversity as antecedents tosupplychainresilience.However,diversityofcommunicationspecifically,languagevariation, clarityofinformationexchangeandpracticeofcommunicatingisanunder-theorizedaspectwithin the supply chain resilience literature (Shokouhyar et al., 2024). Current models mostly define resiliencefromastructuralortechnologicalpointofviewwithoutincludingcommunicationasone ofthestrategicresources.Inaddition,althoughthemanagementofcyberriskhasbeenstudied,its co-operative and inter-organizational dimension has not been sufficiently integrated in resilience models. This is a clear theoretical lacuna in existing frameworks (Sharma et al., 2022).

ContextualGap

Most of the empirical investigations on supply chain resilience is from developed countries with robustinfrastructuresandwell-developedregulation(Abdullahietal.,2025).Insufficientresearch has focused on emerging nations such as Pakistan, where businesses work in a range of cultural settings and weak cybersecurity regime, against infrastructural constraints. Therefore, the theoreticalinferencesbasedondevelopedeconomiesmaynotbeexpectedtoholdtrueforPakistan without proving empirically (Palit et al., 2022).

Practical Gap

From the managerial point of view, organizations receive little direction in terms of how to strategicallymanagediversityfosteringresilience.Inthisrespect,organizationsfacedifficultiesto coordinate the collaborative management of cyber risks among different interdependent entities (Falcone et al., 2024). In the absence of formal (structured) empirical evidence, practitioners are still unsure how relational, technological and communication diversity can be turned into actionable strategies (Qazi et al., 2024).

Table1SummaryofResearchGapsinLiterature

GapType	**Description**	**Supporting Literature**
Theoretical	Communicationdiversityisunder-theorizedin SCR models; CCRM is weakly integrated	Sharma et al. (2022); Shokouhyar et al. (2024)
Contextual	LackofevidencefromPakistanandemerging economies	Palit et al. (2022);Abdullahi et al. (2025)
Practical	LackofimplementationguidanceforCCRMand diversity strategies	Falconeetal.(2024);Qaziet al. (2024)

1.8 Significanceofthe Study

The SCR is thus enriched with the communication function as part of the theoretical construct. In this study, RBV and DC complement definitions about the way general resources together with emergent capabilities are combined to construct resilience. This kind of integration leads to a theoretical novelty since it enlarges the traditional conceptions of SCM.

The impact of this study is also strictly utilitarian and valuable at industrial level for MNC in Pakistan and emerging economies. Findings will provide actionable knowledge about how relationaltechnologicalandcommunicationdiversitymaybeguidedstrategicallytoenhancecyber resilience to risks and disruptions. Focus on collaborative cyber risk management will also drive firms to develop shared strategies for better coordination, addressing vulnerabilities and functioning in an uninterrupted way amid crises.

At an institutional level, value added to Bahria University through locally contested empirical evidence that add on to theliteratureon SC Resilience at global levels.Thesetting of thestudyin

Pakistan’s uncertain and complex environment serves to draw attention to emerging economy involvement in contemporary supply chain research and practice.

1.8.1 Practical Implications

This study offers several practical implications for multinational corporations and supply chain managers operating in digitally connected and cyber-vulnerable environments. First, the findings highlightthatdiversitywithinsupplychainsshouldnotbemanagedinisolation;rather,managers mustalignrelational,technological,andcommunicationdiversitythroughstructuredcoordination mechanisms to enhance resilience.

Second, the strong mediating role of collaborative cyber risk management (CCRM) suggests that firms should move beyond firm-centric cybersecurity approaches and adopt joint cyber risk governance practices with key supply chain partners. These include shared threat intelligence platforms, joint cybersecurity drills, standardized incident-reporting protocols, and crossorganizational cybersecurity training programs.

Third, managers operating in emerging economies such as Pakistan can leverage CCRM to compensateforinfrastructuralandregulatoryweaknessesbypoolingcyberexpertiseandresources across the supply network. This collaborative approach reduces recovery time after cyber disruptions and strengthens supply chain continuity.

Finally, policymakers and industry associations may use these findings to promote sector-wide cybersecurity collaboration frameworks, particularly for multinational supply chains linked to critical industries such as textiles, logistics, and manufacturing.

1.9 Scopeof Research

This study specific is well-specified to provide focus and pragmatism. The MNCs and global supply chain firms in Pakistan, considered in this study, are a logical focus because these organizationsembodythesuitablevariationinrelationship,technologicalandcommunicativeuse that corresponds to the objectives of the research. Managers and professionals in supply chain operations, coordination, and decision-making will be the unit of analysis given that they occupy positions with varying levels of exposure to diversity-related challenges and resilience strategies (Lau et al., 2021).

The research is conducted through a survey and a questionnaire posted online such as Google Formswillbeusedforthestudy.Thisapproachsupportstheeffectivecompilationofstandardised dataacrossfirms.Eventhoughqualitativeevidencecanhelpcontextualizeourunderstanding,the focus should be on quantitative analysis to empirically test the hypotheses formulated.The study is not driven by small, informal, and strictly domestic firms as research should remain applicable to the convoluted supply chains linked internationally.

Table2ResearchVariables,Questions,Objectives,andTheoreticalFrameworks

Variable	**Research Question (RQ)**	**Research Objective (RO)**	**Theoretical Framework**
Relational Diversity	**RQ1:** How does relational diversity affect supply chain resilience?	**RO1:** To examine the impact of relational diversityonsupplychain resilience.	Resource-Based View (RBV), Dynamic Capabilities Theory (DCT)
Technological Diversity	**RQ2:** How does technological diversity influence supply chain resilience?	**RO2:** To evaluate how technological diversity influences supply chain resilience.	Resource-Based View (RBV)
Communication Diversity	**RQ3:** How does communication diversity impact supply chain resilience?	**RO3:** To assess the effect of communication diversityonsupplychain resilience.	Resource-Based View (RBV), Dynamic Capabilities Theory (DCT)
Collaborative Cyber Risk Management (CCRM)	**RQ4:** Does collaborative cyber risk management (CCRM) mediate the relationship between diversity factors and supply chain resilience?	**RO4:** To investigate the mediating role of collaborative cyber risk management (CCRM) betweendiversityfactors and resilience.	Dynamic Capabilities Theory (DCT), Risk Management Framework

1.10 StructureofThesis

The rest of the dissertation is arranged into five main chapters. Chapter one gives introduction to the study and describes its background, statement of the problem, research questions, objectives hypotheses, gap element significance and scope. Chapter Two thoroughly reviews the literature and critiques the prior work on relational, technological and communication diversity, collaborativecyberriskmanagementandsupplychainresilience,withanemphasisonthegapthat was left by existing research. ChapterThree describes the theoretical framework and hypotheses, followed by an extensive explanation of research methodology, which includes research design, sample selection, data collection and analysis. Chapter Four presents the findings and discussion, showing how empirical results are related to hypotheses and previous literature. Chapter Five concludes the study with a discussion of theoretical and practical implications, limitations, and recommendations for future research.

Table3StructureoftheThesis

Chapter	**Title**	**Description**
Chapter1	Introduction	Introduces the study background, problem statement, researchquestions,objectives,researchgap,significance, and scope
Chapter2	LiteratureReview	Reviewstheoriesandpreviousstudiesondiversity,CCRM, and supply chain resilience
Chapter3	Research Methodology	Explainsresearchdesign,philosophy,sampling,data collection, and data analysis techniques
Chapter4	Resultsand Discussion	Presentsstatisticalfindingsandinterpretsresultsinrelation to hypotheses and past literature
Chapter5	Conclusionand Implications	Summarizesfindings,discussestheoreticalandpractical implications, highlights limitations, and suggests future research

CHAPTER2LiteratureReview

2.1 IntroductiontoLiteratureReview

This section explores the theoretical studies on SCR across different industries. The growing complexityofglobalSChasstressedontheimportanceofresiliencyinsupplychains,especially on challenges related to cyber security (Palit et al., 2022). Relational and technological diversity ExistingstudiesServicediversitythatrelatestorelationalandtechnologyhavelargelyemphasized to one of several aspects has shown how these dimensions in collaboration, innovation and adaptability (Ritter & Pedersen, 2020). However, the impact of communication diversity to manifest logogram and variation in terms of language content, clarity, and form/information sharing are significantly under-explored notwithstanding its significance in multicultural supply chains (Shokouhyar et al., 2024).

Moreover,researchershighlightcollaborativecyberriskmanagement(CCRM)asajointresponse measure to protect the supply chain from increasing digital threats. By consolidating these views, theresearchcontributestoourunderstandingofsupplychainresilience(Shokouhyaretal.,2024). The subsequent paragraphs present a review of the literature that considers relational, technological, and communication diversity, CCRM and resilience in a critical way to highlight the gaps that motivate their proposal in practical terms (Falcone et al., 2024a).

2.2 SupplyChain Resilience

SCR is capability of supply chain to predict, prepare, respond, and recover from challenges in a timely manner. SC is resilient when it can withstand disruptions without affecting viability of the organizations (Ganbold et al., 2021). Gao et al. (2016) emphasized that resilience plays a therapeuticroleinpandemics,impactsofclimatechangeandcyberattacks.‘Susceptibility’isoften referred to as the ability for a supply chain to recover from disturbances within a given time and return to its preexisting state (Shokouhyar et al., 2024).

Flexibility,connectednessandtransparencyarealsosomeofthemostimportantcharacteristicsfor making companies resilient. For instance, the automotive industry focuses on these enablers and food processing industry emphasizes supply chain collaboration in information sharing and joint action tasks (Lau et al., 2021).

Dynamic Capabilities Theory (DCT) is often used as the basis for SCR. DCT talks about how a companycancombine,build,andreconfigureitsresourcestodealwithchangesinthe environment. Resilience thus being considered as a dynamic capability which enables supply chains to absorb disruptions and continue to operate (Shokouhyar et al., 2024). This dynamic conceptualization of resilience portrays it not only as a reactive strategy, but also as a proactive abilitytoadaptinthelongtermandevenbecomingastrategicasset(Ruzo-Sanmartínetal.,2024).

Resilience can be described at least along three crucial dimensions: adaptive, robust and recoverable.Adaptabilityischangingstructuresandwaysofdoingthings,ashasbeenseeninthe rapid adoption of digital technologies or altered sourcing during the COVID-19 pandemic (Di Maria et al., 2022). Resilience is related with redundancy, flexible contracts and multi-sourcing whereasrobustnessimpliesthatfunctionscanbepreservedunderdisruptionsfthasbeenshowna direct relation between relational diversity and network resilience (El Amin et al., 2024), with relational diversity enhancing network robustness. Recovery focuses on returning to normal operations,withcollaborativecyberriskmanagement(CCRM)playingavitalroleinaccelerating recovery from cyberattacks (Oriola et al., 2021).

Several models have been developed to conceptualize resilience Kleist (2021) propose a balance betweenvulnerabilities(e.g.,turbulence,resourcelimitations)andadaptivecapabilities.Abdullahi etal.,(2025)emphasizesreadiness,response,recovery,andgrowthaskeystagesinresilience.Cao et al., (2024) identify four principles: re-engineering, collaboration, agility, and risk management culture,highlightingtheneedforresiliencetobeembeddedinbothcultureandprocesses.Nguyen etal.,(2021)applysystemstheorytoexplainresilienceasadynamic,evolvingprocessinfluenced by real-time responses and digital technologies.

2.3 RelationalDiversity

Relational diversity the interpersonal, cultural and organizational relationships at a supply chain partnersandthetrustbuildingreflectedbyvariationsininter-partnercollaborativestyles(Awan& Ali, 2022). Different from the homogenous chains, relational diversity may offer different views that could lead to unforeseen innovation or adaptation by firms being confronted with a larger variety of knowledge bases. Relational diversity, if not managed well, can result in misunderstandings and conflicts and cause trust deficit (Khan et al., 2024).

Trust is essential in relational diversity due to level of information and resources involved in companies.Trustensurescollaboration,knowledgesharingandutilizationofcomplementaryskills duringinformationsharing(Qazietal.,2024).However,culturalmisunderstandingsarerelatedto relational diversity and therefore, effective conflict management strategies and transparent collaboration are required to counter these challenges (Kleist, 2021).

Existing studies of supply chain collaboration have focused on relationship type and stages, includingtransactional,relational,andsynchronizedrelationships(Liuetal.,2024).Diversitycan act as a challenging process for either increasing resilience via integration or introducing waste throughdiversificationbythemannerofitsmanagement(Kumaretal.,2024).Trust,commitment, reward systems and power among the supply chain members are important factors affecting collaboration. Sirmon et al., (2011) suggested that interfirm information sharing, decision alignment, and incentive alignment are prerequisites to successful collaboration. Information sharing is how effectively supply chain members communicate, decision alignment coordinate decision making at multiple levels. Aligning incentives provides partners with shared risks and rewards. Creazza et al., (2022) then proposed seven dimensions of collaboration for goal congruence, communication efficiency, and joint knowledge creation as the origin for many following papers. Falcone et al., (2024) used these elements to examine their role in supply chain resilience. However, the literature lacks detailed conceptualization of collaboration in network resilience settings. Furthermore, most studies focus on developed economies, leaving a gap in understandinghowrelationaldiversityaffectsresilienceinemergingmarketslikePakistan,where challenges such as weak governance and infrastructural constraints prevail (Awan &Ali, 2022).

2.4 TechnologicalDiversity

The innovative use of digital technology to enhance organizational operations and capacity is known as digital transformation (Khurana et al., 2022).It is an element of process that induces a leveloftransformationthroughthecombinationofinformation,computation,communicationand connectivity (Nwankpa et al., 2022). In contrast, technological diversity is the range of digital platforms, IT infrastructures and systems that supply chain members utilize. In the digital world, modern organisations depend on ERP, cloud computing, blockchain, AI and the IoT to run its ecosystems.Althoughavailabletechnologiesimproveoptimizationandrationaldecision-making, theircoexistenceraisesnewchallengesofintegration,interoperabilityandstandardization(Caoet al., 2024).

With the advent of Industry 4.0, the call for digital integration in supply chain has become more resounding. Partners may operate on different systems, including older ones and the latest cloud services.Itmakesverydifficultforthemtocollaborateandexchangedata,whichledtothat pressureofnotexchangingorthewasteofexchangingdata(Caoetal.,2024).Thesegapscanalso makethenetworkopentocyberthreats(B.Yangetal.,2024).Buthavingavarietyoftechnologies canmakeacompanymoreflexible,sincecompaniesthatusemorethanonesystembecomemore agileandadaptable(Nguyenetal.,2021).Forexample,companiesthathadERPsystemintegration with could platforms showed better agility in their operations during COVID19 pandemic.

According to RBV, digital technologies provide a competitive advantage in managing organizational resources (Qazi et al., 2024). In addition, these digital technologies help in developing organizational capabilities to withstand disruptions.Therefore, SCR can be increased by integrating more technologies in the organizations (Nayal et al., 2022). Nevertheless, heavy technologydiversitymayleadtoinefficiency,andlessdiversitycouldsuppresscreativity(B.Yang et al., 2024).

Oneofthemostimportantthingstounderstandishowdifferenttypesoftechnologyarerelatedto cyberthreats. Given that supply chains are based on heterogeneous systems, a broader frontier of attack is opened for cyber-threats, thus requiring collaborative risk management (Ta et al., 2024). Good risk management demands systems and sharing of information among partners. Despite somestudies,thereexistsalackofresearchontechnologydiversityinemergingcontextssuchas the firms are hindered by poor infrastructure, and they have less developed security capabilities (Chowdhury et al., 2023). Filling in this gap is important since resilience measures would not necessarily extrapolate from developed countries to the emerging markets such as Pakistan.

2.5 Communication Diversity

Diversity of communication is the diversity in language, precision of a message, ways of transmitting information and communication style between supply chain nodes. Communication has always been important and now, in today’s global economy where supply chains cross many countries,culturesandlanguages,itisvitalforcoordinationandefficiency(Rahmanetal.,2025). Communicationdiversitystudiestheeffectofcommunicationbarrierssuchasproficiency,cultural normsandcollaborationthatareevidentinMNCsastheyarecharacterizedbymulticulturalteams andcross-borderinteractions(Ganboldetal.,2021).Therefore,itisessentialtohavemultilingual workforceasitallowspeopletointeractindifferentlanguagesandcanaccessnewmarketsaswell. (Baiyere et al., 2020). Even among individuals who speak the same language, such as English, differences in skill and comprehension can result in mismatches. Different languages make transactions more expensive and make people less trusting (Di Maria et al., 2022).

Furthermore, differences in language may create coordination failures where misinformation or unequal awareness produces non-complementary intentions and lags timewise (El Amin et al., 2024).Thatcouldbecrucialinanemergency,whentimelycommunicationmightkeeppeoplesafe or limit destruction. During disasters or supply chain disruptions, different negotiation behaviors will affect the efficiency of just-in-time information exchange with consequent longer recovery times.Thesepressuresreducethedemandforindustry-widepoliciesandprocedures(Oriolaetal., 2021).

Resilience means supply chains bouncing back or emerging stronger, and all must be flexible. During challenging times, it is these networks that are the lifeblood of resilience and the “glue” that binds everything together. The importance of collaboration is recognized yet the empirical profileofitsimpact,particularlyindevelopingcountries,isstilllacking(Warner&Wäger,2019). thecurrentstudyexaminesthefoodnetworkinPakistan,anationthatsuffersfromfloodingleading toalossofUSD30billionoversixdecades.Regardlessofchallengesfaced,thefood-supplychain continues to function in Pakistan which creates an apt setting for researching collaboration in disaster (Shoomal et al., 2024).

The final main issue here is the communication diversity to cyber fragilities connection. Poor communication of cybersecurity responsibility leaves supply chains indiscriminately vulnerable. Whenasupplierdoesnotreportaphishingattemptbecausethecommunicationisnotclear,itcan endangerthenetwork.Academicsconsiderthatpoorcommunicationsdetrimentofcyber-security (Shishodia et al., 2023).While there are risks, diversity in communication is also an opportunity. It encourages innovative problem-solving, and the firms that embrace it are investing in crosscultural training, translation technologies and a standardized reporting system, all of which make them more resilient. Communication diversity can also provide a competitive advantage by equippingfirmswithculturalandlinguisticknowledgetooperateinmultiplemarkets(Palitetal., 2022).

2.6 Cybersupplychainriskmanagement

Cybersupplychainriskmanagement(CSCRM)isanemergingconceptcombiningcybersecurity, enterpriseriskmanagement,andsupplychainmanagementpractices.Inthepost-9/11era,sectors such as global manufacturing and energy have increasingly adopted enterprise risk management (ERM) to mitigate operational risks (Stadtfeld & Gruchmann, 2024). Initially developed within manufacturing,supplychainmanagementhasnowbeenextendedtovariousservicesectors.The concept of cybersecurity that was born as the outcome of ITintegration has been largely realized acrossdifferentsectorsworldwide(Sharmaetal.,2022).CyberSecurity,ERMandSupplyChain Mgthaveeachcreatedtheiruniquebodyoftheory,professionalpractice,andbodyofknowledge.

Unlike traditional cybersecurity, CSCRM focuses on gaining visibility and control not only over thefocalorganizationbutalsoitsextendedsupplychainpartners,includingTier1/Tier2suppliers and customers. It integrates both managerial and human factors engineering to mitigate disturbances in the system (Palit et al., 2022). Whereas conventional enterprise risk management ishierarchicalandstatic,CSCRMrecognizesthefluidnatureofadaptiveITnetworks.Inaddition, different from supply chain management, CSCRM must face the dynamic demand and fuzzy identities of supply chain provider. Cyberattacks are growing more sophisticated, which demonstratesthattechnicalsafeguardsalonecan'tsuffice.Thisismorecomprehensive(Abdullahi et al., 2025).

2.7 CollaborativeCyberRiskManagement

CCRM is the teamed actions of companies and their business partners for working together to watch, identify, and block cyber risks. Classic Risk Management typically focused on risk within anorganization.Incontrast,CCRMfocusesmoreoncollaboratingandapportioningownershipof the cybersecurity between organizations (Qazi et al., 2024). Reliance on digital technology has grown across super-connected global supply chains, so problems in one partner's system can cascade around the planet. This interrelatedness makes the decision to act in concert simply a strategic imperative for resilience (Kleist, 2021).

As an element of supply chain resilience, CCRM stresses collaborative monitoring and threat identification. Partners can innovate and create real-time monitoring capabilities of digital infrastructuresandthreatintelligencebasedontheircorecompetencies.Thisallowsbusinessesto be able to detect threats like phishing or malware at a very early stage (Shokouhyar et al., 2024). Shared technologies such as blockchain and cloud systems are some of the shared technologies that make it easier to understand what is happening at different stages of the supply chain. This reduces the chances of undetected breaches and facilitate rapid responses to new threats (Queiroz et al., 2022).

Havingcoordinatedresponsescanalsominimizecostsanddisruptions.Businessesthatoperatein silosprovidedisjointedresponses,andcrisesdragon.Butcoordinatedstrategicplanningunites containment, communication and recovery. It has been empirically verified that the cooperative informationexchangebetweenmembersandcommonsimulationdramaticallydecreasethewaste of recovery time and damage (Cao et al., 2024).Answers like these can also be a part of building trust, and making it easier for people to mesh in more complex ways at larger scale.

Asecond important element of CCRM is collective responsibility in the sense that organizations jointly establish group-wide compliance standards by collaborating on security technology. Such pooling of resources and expertise promote knowledge spill-over across firms and adjust to the continuously changing nature of cyber threats (B. Yang et al., 2024). The benefit from such standardsisthatweaknessesinthesupplychainarenottransmittedtotheentirevaluechains(Lau et al., 2021).In the logic of RBV, CCRM pretends to develop valuable and rare resources that further enhance long-term competitiveness (Nguyen et al., 2021).

But there are large gaps, particularly in the regions of the world that are still growing. Most of these studies are conducted in industrialized economies with well-established infrastructure and regulatory systems, which enable the development of collaborative arrangements (Chowdhury et al., 2023).In places like Pakistan, companies struggle with issues including a lack of awareness about cyber security, too few resources allocated to digital security and poor enforcement of regulations.EventhoughthemajorityofMNCsactaccordingtoregulations,itishardtofindthose tools/systemsavailableinlocalpartners.ThisprovidesthenecessitytoevaluateCCRMoperations in developing countries where resilience can be enhanced by engaging various stakeholders to rectify structural deficiencies (Rahman et al., 2025).

Theinclusionofcollaborativecyberriskmanagementasamediatingvariableistheoreticallyand empirically justified. From a Dynamic Capabilities Theory perspective, CCRM represents a higher-order capability that enables organizations to sense cyber threats, coordinate inter-firm responses, and reconfigure digital resources across organizational boundaries. While relational, technological, and communication diversity introduce complexity and exposure to cyber risk, these diversity dimensions alone do not automatically translate into resilience outcomes. CCRM acts as a transformation mechanism through which heterogeneous resources are integrated and mobilized into coordinated defensive and recovery actions.

Empirically, recent studies indicate that collaborative approaches to cyber risk significantly enhancedisruptionrecoveryspeedandsupplychaincontinuitycomparedtoisolatedfirm-level practices (Cao et al., 2024; Rahman et al., 2025). Therefore, positioning CCRM as a mediator allowsthisstudytoexplain*how*and*why*supplychaindiversitycontributestoresilience,rather than merely establishing direct associations.

2.8 TheoreticalFoundation

This research integrates RBV and DCT theories to examine relationship between supply chain diversity,CCRMandresilience.Thesetheoriesexplorediversity,flexibilityanddisruptionsinthe supply chain. RBV corresponds resources as unique, valuable, rare, inimitable, and nonsubstitutableasstipulatedby(Stadtfeld&Gruchmann,2024).Relationaldiversitystrengthens networksthroughtrustandtheexchangeofknowledge,equipsfirmswithabroadrangeofITtools toenhanceadaptability,andcommunicationdiversityintroducesmultipleperspectivesthatenrich decision-making and problem-solving (Palit et al., 2022).

DCT is a development of RBV that emphasizes adaptation and renewal of resources in dynamic context (Sharma et al., 2022). Whereas RBV is about the possession of valuable resources, DCT speaks to the recombination of these resources in response to changes. In this paper, resilience is regarded as a dynamic capability for organisations to prepare for, absorb and recover from disruptions.CCRMcapturesthisbyallowingacoordinatedthreatsensingandresponseactivityas well as a continuous adaptation with respect to the cyber risks (Falcone et al., 2024a). The amalgamationofRBV,andaswellDCZinthisresearchprovidedacomprehensiveunderstanding on how diversity and collaborating mechanisms improve the resilience within supply chains, especially in developing economies such as Pakistan (Qazi et al., 2024).

2.9 JustificationforUsingRelational,TechnologicalandCommunicationDiversityTogether

Relational,technological,andcommunicationdiversityarenotindependentorisolateddimensions insupplychainoperations;rather,theyinteracttoshapehoworganizationscoordinate,adapt,and respond to disruptions. Studying them separately would ignore their joint influence on resilience and provide only a partial explanation of supply chain behavior.

Relational diversity determines *who* organizations collaborate with, technological diversity determines *how* they work together through systems and platforms, and communication diversity determines *how effectively* information flows among partners. Somehow or other, though, relationaldiversitywithnotechintegrationandcoordinationisslowandpiecemeal.Similarly,no amountoftechnologicalknow-howcanmakeupforlackoftrustandit’shardtohavehealthy relationships without good communication. Diversity of communication serves as the functional conduit between relationships and technology.

The three diversity dimensions are derived from the Resource-Based View (RBV) as complementary resources within the organization. Together, they have more strategic value than individually since the co-deployment raises personal difficulty of imitation and technological capability. That is, for Dynamic Capabilities Theory, resilience does not come from holding resources per se; it comes as the capability of dynamically integrating and reconfiguring them whenadisruptionappears.Theinterplayofrelational,technologicalandcommunicationdiversity allows supply chains to sense threats early and to coordinate responses and rebound from impact more quickly.

Hence, integrating these three variables creates a comprehensive understanding of supply chain resilience by incidencing human-technological-informational dimensions within the same framework.This combined framework enhances theoretical completeness as well as the practical relevanceofresults–especiallyinsituationswhereallthreefacetsofdiversityappearatonceand interact under high uncertainty.

2.10 SummaryandResearchGap

Diversity in supply chains and performance the literature illustrates how relational, technological andcommunicationdiversityimpactonSCoutcomes.Relationdiversitypositivelyfacilitatestrust, collaboration, and innovation but can also have negative effects such as conflicts. Range of technology enables adaptability and innovation but creates issues of interoperability and cyber security. If diversity in communication is at the heart of clarity and coordination, it is relatively unexamined in supply chain research.

The concept of CCRM is perceived as an essential enabler that builds resilience through mutual surveillance,synchronizedreactionandcollectiveresponsibility.Itisrecognizeditsimportancein advanced economies, however empirical studies from emerging markets such as Pakistan are scarce where infrastructure gaps and weaker cyber security systems escalates the risks.

This study aims to fill the void by blending the RBV with DCT. RBV positions diversity as a strategicresource,whileDCTframesresilienceasadynamiccapability.Together,theyjustifythe proposed framework and hypotheses linking diversity, CCRM, and resilience.

2.11 ConceptualFramework Discussion

Figure 2.1 illustrates the theoretical model for this study. It presents relational, technological and language diversity as autonomous factors which condition supply chain resilience. Strategical management to integrate different behavior The Collaborative Cyber Risk Management acts as a go-between which, in the best of cases, turns complexity stemming from heterogeneity into coordinationensuringgreaterresilience.Thearrowsindicatehypothesizedrelationshipsthatareto be tested within the context of Resource-Based View and Contingency Theory. Each of these hypotheses is based on the literature reviewed in this chapter and that rich, nuanced relationship between diversity, collaboration and resilience in a digitally fragile supply chain environment.

2.12 Hypotheses Development

Drawing from a literature review and theoretical underpinning from RBV and DCT, this study developshypothesestoinvestigatetherelationshipbetweensupplychaindiversityandresilience, as well as the mediating influence of CCRM.

2.12.1 RelationalDiversityandSupplyChainResilience

Relations' diversity gives rise to collaboration, trust formation, access to diverse type of knowledge. Developed from RBV, relationships are valuable and inimitable organizational resourcesthatincreaseadaptabilityandcoordination.Empirically,oneofthereasonsorganizations that have more diverse partners perform better in the face of disruptions is because diverse networks offer more support.

H1: Relationaldiversityhasasignificantpositiveeffectonsupplychainresilience.

2.12.2 TechnologicalDiversityandSupplyChainResilience

Technology diversity is also another form of insurance, alternative systems, options and innovation.WithDCT,firmscanreorganizeandadjustoperationsinsituationsofadversitydueto technological capability. Too much heterogeneity is inefficient, but moderate diversity helps bolster the resilience and recovery.

H2: Technologicaldiversityhasasignificantpositiveeffectonsupplychainresilience.

2.12.3 CommunicationDiversityandSupplyChainResilience

Clarity,coordinationandspeedofresponseareaffectedbydiversityofcommunications.Fromthe RBV, effective communication processes are strategic resources of the organization. Studies suggest that communications breakdowns exacerbate operation and cyber disruptions.

H3: Communicationdiversityhasasignificantpositiveeffectonsupplychain resilience.

2.12.4 CollaborativeCyberRiskManagementandSupplyChainResilience

CCRM enhances awareness, readiness and co-ordinated response to cyber threats. We argue that joint risk management forms a dynamic organizational capability that increases resilience in the face of crises.

H4: Collaborative cyber risk management has a significant positive effect on supply chain resilience.

2.12.5 MediatingRoleofCollaborativeCyberRiskManagement

Relational, technological and communication variabilities increase resilience indirectly through facilitatingcybercooperation.RBVjustifiesCCRMasanidiosyncraticcapabilitydevelopedfrom alliance, and DCT verifies its effect on dynamic response.

H5:CCRMmoderatestheimpactofrelationaldiversityonsupplychainresilience.

H6: Technologicaldiversityhasanindirecteffectonsupplychainresiliencemediatedby CCRM.

H7: Therelationshipbetweencommunicationdiversityandsupplychainresilienceismediatedby CCRM.

Table4HypothesesFramework

Hypothesis	**Relationship**
H1	RelationalDiversity→SupplyChainResilience
H2	TechnologicalDiversity→SupplyChainResilience
H3	CommunicationDiversity→SupplyChainResilience
H4	CCRM→ SupplyChain Resilience

H5	RelationalDiversity→CCRM→ Resilience
H6	TechnologicalDiversity→CCRM→Resilience
H7	CommunicationDiversity→CCRM→Resilience

H1: Relationaldiversityhasasignificantpositiveeffectonsupplychainresilience.

H2: Technologicaldiversityhasasignificantpositiveeffectonsupplychainresilience.

H3: Communicationdiversityhasasignificantpositiveeffectonsupplychain resilience.

H4: Collaborativecyberriskmanagementhasasignificantpositiveeffectonsupplychain resilience.

H5:CCRMmoderatestheimpactofrelationaldiversityonsupplychainresilience.

H6: TechnologicaldiversityhasanindirecteffectonsupplychainresiliencemediatedbyCCRM.

H7: Therelationshipbetweencommunicationdiversityandsupplychainresilienceismediatedby CCRM.

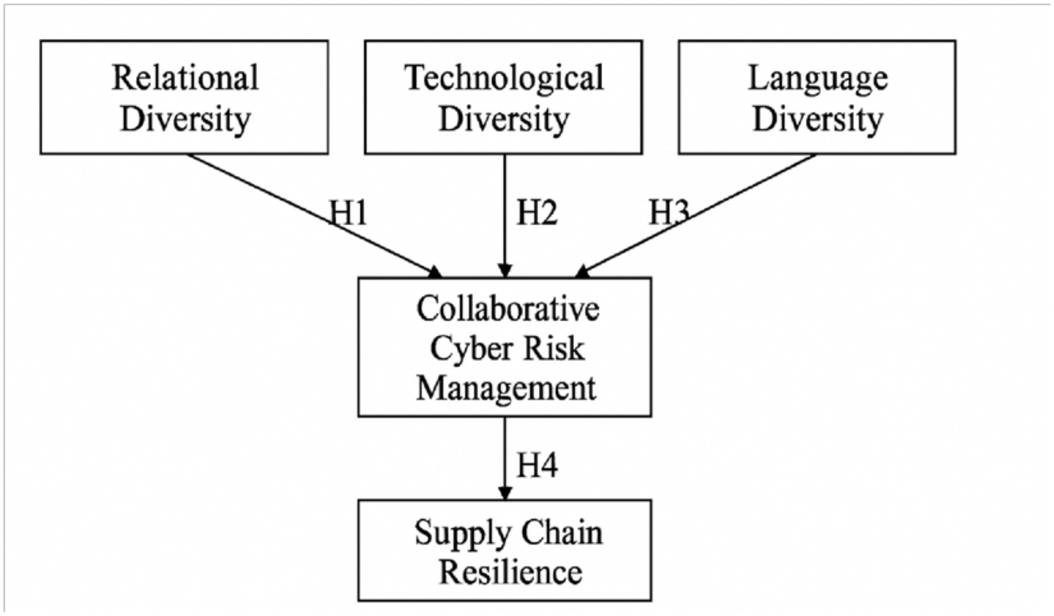

Figure1TheoreticalFramework

CHAPTER3Research Methodology

3.1 Introduction

This chapter presented the method used to study t8he influence of Relational Diversity, Technological and Communication diversity and CCRM on SC resilience in MNCs present in Pakistan.Awellthoughtoutmethodologyensuredthattheresearchquestionsandstudyobjectives were robustly addressed in a manner which was valid, reliable and rigorous (Palit et al., 2022).

Thestudywasdesignedtoexplorehypothesizedassociationsusingamultimeasurementapproach combining quantitative and qualitative components. Quantitative approaches were prioritized to yield specific and generalizable results, with qualitative explanations being collateral in order to provide perspective context (Shokouhyar et al., 2024). the survey method was used as the main instrumentforcollectingdata.Additionalqualitativeinformationprovidedbysurveyrespondents further enriched and grounded the statistical findings.

In general, in this chapter the research philosophy, approach and design, the population and sampling, the data collection and analysis, and the ethical considerations for the study were explained.Thesemethodologicalchoiceswereconsistentwiththeaimofthestudyandguaranteed that the findings were academically rigorous, as well as practically focused.

3.2 ResearchPhilosophy

The research philosophy that underpinned this study is positivism that assumes that social phenomenacanbeobservedobjectivelyandmeasured.Positivistwasalsosuitableasthepurpose of the research was to test hypotheses on the impact of relational, technological, and communication diversity with CCRM on SC resilience (Shokouhyar et al., 2024). In taking this position, the investigation could only draw valid and generalizable conclusions using empirical data and rigorous testing methods.

Theresearchalsoadopteddeductivelogic,startingwithestablishedtheoriessuchastheRBVand theDCT(Awan&Ali,2022).Thetheoreticalbasewasusedtoderivehypothesesthatweretested withdatafrommanagersworkinginthecontextofmultinationalcorporations(MNCs)inPakistan. Deductive approach was well-suited for this study because theory development was not an objectivebuttestingtheapplicabilityandextensionofexistingframeworksinanunder-researched context was (Khan et al., 2024).

Toincreaserigor,amulti-methodstudywasconductedtoincreaserigor.Quantitativeapproaches, including surveys using structured questionnaires, yielded data that were measurable and hence amenable to statistical analysis. Qualitative data were also collected with open ended responses and from manager discussions for contextual depth (Qazi et al., 2024). In combining these methodologies, the research was able to take advantage of the objectivity of quantitative research while incorporating the depths of qualitative insights thus achieving a balance and thorough level of understanding of the research problem.

3.3 ResearchApproachandDesign

an explanatory research design, was used to explore the causal relationships between diversity dimensions relational, technological and communication collaborative cyber risk management (CCRM) and supply chain resilience. This design was appropriate because it extended the descriptionbeyondthevariablestoexplaininghowandwhythevariableswereinterrelatedwithin multinational corporations (MNCs) in Pakistan. Grounded in existing theories and assumptions, the explanatory design offered a structured empirical journey to verify (Queiroz et al., 2022).

Themainmethodwastogatherthedatausingacross-sectionalsurveydesign.Cross-sectionaldata werecollectedthroughanonlinestructuredquestionnaireofmanagersandprofessionalsinsupply chainpositionatonepointintime.Therelationshipsamongstudyparticipantswereassessedusing across-sectionaldesignandanalyzedbetweendependentandexplanatoryvariables(Abdullahiet al., 2025). The participants' responses were assessed using a five-point scale model.

Open-endedquestionswereusedtogetreliableinformationabouthowtounderstandthestatistical outputfromPakistanisupplychains.Responsesinthedatadisplayedissuesaroundcommunication andinfrastructurethatistothedetrimentoflocalbusiness.Hence,theinterplayofcross-sectional surveys and qualitative analyses enabled the theoretical relationships to be examined, including diversity and cyber risks across complex supply chain settings.

3.4 Populationand Unit ofAnalysis

Theselectioncriteriaoftheparticipantswerebasedontheirpracticalexperienceincommunication andahighdegreeoftechnologicaldiversityacrosssupplychainnetworks.Thus,themanagersand professionals of MNCs in Pakistan were selected as they were directly involved with decisionmaking, network coordination systems, technological systems and risk management control.

Becauseoftheirextensivedigitalintegrationanddependenceonglobalsuppliers,participantswere viewedashavingstrategicandtacticalexperiencewiththeinfluenceofdiversityandcooperation on supply resilience.

Second, managers in Pakistan's MNCs were situated at the crossroads of global norms and local practices. They were expected to apply the best practices of the world and yet to work with one hand tied behind the back with limited infrastructure and cultural and security awareness in the localenvironment.Theirexperiencemadethemthebestparticipantstogiveanempiricalviewon how diversity and CCRM impacted on supply chain resilience in emerging markets.

3.5 Sampleand SamplingTechnique

Thesampleforthisresearchwasof200–300managersandprofessionalshavingjobexperiencein multinational corporations (MNCs) and global supply chain companies in Pakistan. This number of cases was chosen as being appropriate to conduct statistical analyses like SEM, regression otherwise requiring a higher number of observations for reliability and validation. By targeting managers, this study also guarantees the respondents to possess enough decision-making experience and knowledge on supply chain management, diversity management and cyber risk preparedness.

Duetothepracticalandaccesslimitations,aconveniencesamplewasused.Gainingaccesstothe managersofMNCsisfrequentlydifficultbecauseofconfidentiality,gatekeepingbyorganizations and sensitivity of information concerning risk management. The use of convenience sampling made it possible for the researcher to gather data from those respondents who were available and willing through professional networks, LinkedIn links, and company connections. While this approach reduced generalizability, it was a methods style to be able to access many the relevant respondents relative to the limited time had to conduct the survey.

The use of convenience sampling was also appropriate given the exploratory and explanatory orientationoftheresearchintendedtotesthypothesesunderanemergingmarketenvironmentwith restricted data availability. The sample size collected was felt-to-be satisfactory to address the relationships of diversity, CCRM and supply chain resilience in MNCs in Pakistan.

3.6 Instrument Development

Theprimarydatacollectioninstrumentforthisstudywasa**structuredquestionnaire**,whichwas designedandadministeredelectronicallyusingGoogleForms.Thequestionnairewasselectedas the most suitable tool because it allowed for standardized data collection from a relatively large sample of managers across multinational corporations (MNCs) and global supply chain firms in Pakistan.Electronicdistributionalsofacilitatedaccessandease,allowingrespondentsremotefrom the setting to participate easily.

Questionnaire items were formulated based on validated instruments to assure reliability and constructvalidity.A5-pointLikertscalewitharesponserangefrom(1=StronglyDisagree)to(5 =StronglyAgree).Thisscalewasselectedasitprovidesparticipantswiththeoptionofexpressing the extent of agreement or disagreement and is suitable to measure perceptions and attitudes towards diversity, CCRM and resilience.

Theconstructswere**operationalized**as follows:

- **Independent Variables (IVs):** Relational diversity, technological diversity, and communication diversity were measured using items capturing collaboration styles, technological heterogeneity, and communication practices, respectively.
- **Mediator:** Collaborative cyber risk management was assessed by a score of joint monitoring, responses of partners, and shared responsibility within the partnership.
- **Dependent Variable (DV):** Supply chain resilience was defined in terms of adaptability, robustness, and recovery.

Thesurveyincludeddemographicvariablessuchasage,industrytype,experienceinmanagement and organization type to facilitate contextual analysis and interpret results based on background variables.

3.7 DataCollection Procedures

Questionnairewasdevelopedusinggoogleformstogatherdata.Differentsocialmediaplatforms such as LinkedIn, emails, contact messages, were used to contact managers and professionals working in MNCs and global supply chain companies in Pakistan. This approach helped in reaching out to audience across industries and the unique challenges that they encounter due to cyber threats in their respective organizations. Pilot testing of the questionnaire was done on 30 samplestocheckthеclarity,validityandrelevanceofquestions.Theminoradjustmentsweremade withtheaimofachievingaccuracyandfitinallitemstoattempttoassureconsistencybetweenthe scales.The survey was available for 12 weeks to encourage response rates with follow-up emails and messages used for yield meaningful statistics.

3.8 DataAnalysisTechniques

Thedatawasanalyzedfordescriptivestatistics(mean,standarddeviation,frequencyandpercent) to describe the demographic profile of respondents and also to report central tendency and variability in the classes of constructs.This gave a general sense of the distribution of patterns in the dataset.

For inferential analysis, correlation and regression was used, as well as Partial Least Squares Structural Equation Modeling (PLS-SEM) to check for variables associations and evaluate direct and indirect relationships. Correlations assessed the magnitude and direction of relationships, while regression determined the predictive value of relational, technological, and communication diversity towards supply chain resilience (SCR). The PLS-SEM, appropriate to complex models oflatentvariables,wascarriedoutbyusingSmartPLS,whereasSPSSforthedescriptivestatistics and correlations and regressive statistical analyses.

ReliabilitywasestablishedbymeansofCronbachsalphatestforinternalconsistencyandconstruct validity with convergent validity (tested through AVE and factor loadings) and discriminant validity (by using Fornell–Larcker & HTMT criterion). CFA was used to demonstrate how the items were accurately reflecting each construct.

The PLS-SEM model included a measurement model that relates observed variables to latent variables, and a structural model capturing relationships among constructs. Path coefficients and confidenceintervalsweretestedusingbootstrappingwith5000samplesatasignificancelevelof .05. Histograms of the path coefficients, outer weights and indirect effects had also been created to visually represent data distribution and significance. These strong statistical procedures guaranteedreliabilityandvalidityofthemodelandprovidedtocapturecomplexinterrelationships among CCRM, diversity dimensions, and Supply Chain Resilience.

3.9 Ethical Considerations

Ethical issues All subjects rights and welfare were respected during data collection as per the ethical consideration’s principles of this study. All participants provided informed consent. Participantswereintroducedtothestudyaims,objectives,atimeestimateforstudycompletion andstagesincompletingeachsectionofthequestionnaire.Theywereinformedthatparticipation was completely voluntary and that they could withdraw without consequences at any time.

To maintain the confidentiality and anonymity of participants, no other information that could possibly identify respondents (e.g., names, email addresses, or affiliation with an organisation) were collected unless participants provided it themselves in open-ended comments. Responses wereaggregatedforanalysis,suchthatnoneoftheindividualanswerscouldbeidentifiedwithany of the respondents.

Alldatawasstoredinasecure,passwordprotectedfileandonlyaccessiblebytheresearcher.The data collected on Google Forms was downloaded and encrypted in a secured computer, with a periodicbackuptoavoidlossbyaccident.Allinformationwasutilizedforacademicpurposesonly and not provided to anyone that's unauthorized by medical ethics.

3.10 LimitationsofMethodology

Aswithallempiricalstudies,thisstudyalsohadsomelimitations.Themostpressingofthesewas thesamplingstrategyused,aconveniencesamplethatmayhaveintroducedbiasalthoughthiswas pragmaticintermsofaccess.Giventhattherespondentswerethosewhowereavailableandwilling to participate in the survey, this sample may not have been fully representative of the entire populationofmanagersworkingatthelevelofmultinationalcorporationsandglobalsupplychain companies in Pakistan. This restricts the generalizability of the results to all industries and types of organization.

Afurtherlimitationwasthecross-sectionalperspectiveofthestudydesign,whichrepresentsonly asnapshotatagiventimepoint.Althoughusefultotesthypothesizedrelationships,suchadesign couldnotbeusedtoobservechangesinresilience,diversity,andcyberriskmanagementpractices across time. Moreover, the use of self-report data was sensitive to social desirability bias, since managers may have used the survey to present a more positive image of their organization. However, with these limitations, the selected approach was still suitable for the purpose of exploring the research questions and generated valuable insights into the domain of supply chain resilience in Pakistan.

3.11 ChapterSummary

This chapter explained the methodological approach that was applied in conducting the study. It describedtheresearchphilosophy:positivist,andthedeductivereasonthatunderpinnedthe explanatorydesignwithreferencetoacross-sectionalsurvey.Thepopulation,sample,andunitof analysis were defined, with managers in MNCs identified as the most relevant respondents. The structuredquestionnairewascreatedusingvalidatedstatementsonafive-pointLikertscaleacross all the independents (i.e., mediator and dependant) variables. The research methods – data collection, pilot test and application of SPSS and SmartPLS were presented for the analyses and statistical technique applied for reliability and validity. The importance of ethical issues, such as informedconsent,confidentialityandsecurityofdatastorage,wasstressed.Thesectionendedby talking about the problems with the methods used, especially convenience sampling and generalizability.Overall,themethodologymadesurethatthestudywasboththoroughanduseful in meeting its goals.

CHAPTER 4Results

The findings of the PLS-SEM analysis are presented and discussed in this chapter. The analysis has been performed on the simulated_scm_ccrm_dataset with stringent parameters which are meant to obtain robust and reliable results. Up to 3,000 iterations were set as convergence limit (stopcriterionof),guaranteeingaccuratemodeloutput.Thereliabilityoftheresultswasreinforced by the number of bootstrap samples (5000) provided and percentile bootstrap intervals for confidenceintervals.Hypothesistestingwasconductedatasignificancelevelof0.05toavoidthe consideration of relationships that are unlikely to be statistically significant.The model consisted of an inner and outer model. The inner model examined the correspondence between focal constructs, in particular, CCRM was posited to have impact on other constructions namely CD, RD,TDandSCR.1.000ontheminthemodel),reflectthereflectivenatureofpredictiveconstructs leadingtohighcorrelationsasfactorswiththeirindicators(Moseretal.,2017).Thespecificouter model, that contained the indicators of each construct loaded all items -1.000, indicating a high strong but possibly inverse relationship with negative loadings to imply a reverse coding and consequently might reflect such as highly on the development of new scales measuring those constructs in future studies.

Histograms for path coefficients, indirect effects and total effects in the analysis convey an overview of magnitude and directions some relationship between constructs involved. The histogramofpathcoefficientsshoweddatesoftherelationships,iftheyarelargeenoughandwith a statistical significance.The indirect effectshistogram demonstrated themediating role ofCCRM, and a total effects histogram integrated both direct and indirect influences to estimate the magnitude of each path taken together. These histograms are interpreters so to enable one to get the feel for the statistical significance of each relationship, particularly whether the confidence intervalsaroundapathcoefficientcontainzero(0)whichindicatestheeffectisinsignificant.The findings of the model proposed that both relational diversity and technological diversity as well communication diversity positively affect supply chain resilience in case of MNFs operating in Pakistan.Importantly,CCRMwasestablishedasasignificantmediatingmechanism,meaningthat CCRMplaysanenhancingroleintherelationshipofdiversityfactorswithsupplychainresilience. Co-determinationoftheindirecteffectsanddirectrelationships,however,supportsourassumption that CCRM is instrumental in increasing SC resilience by virtue of its interactions with other diversity dimensions. In sum, the PLS-SEM analysis has demonstrated support for relational, technologicalandcommunicationdiversityintermsofinfluencingsupplychainresilienceaswell asemphasizedthemediatingroleplayedbycollaborativecyberriskmanagement(CCRM)insuch relationships. These results contribute significantly and help in understanding how diversity dimensions have potential to strengthen supply chain resilience which is particularly significant for MNCs operating in Pakistan.

4.1 PathCoefficientsandStatistical Significance

Figure1showsthepathcoefficientsresultingfromPLS-SEManalysisandindicatingthestrength and direction of the relationships among CCRM, SCR and main diversity dimensions—communication, relational, technological. These coefficients and their respective histograms altogether corroborate the stability, importance, and reliability of the model relationships. The CCRM -> SCR relationship histogram clearly draws around a normal distribution with path coefficient about 0.701 (as the value of original sample). This implies a positive and high relationshipthemoreyouhaveonCyberriskmanagement,strongersupplychainresilience.Model stability is supported by homogeneity of simulation and narrow 95% confidence interval (0.639–0.762).Thebiascorrectedinterval(0.632–0.756)reinforcesthestrengthofthisresultandreduces the potential impact of sampling bias.

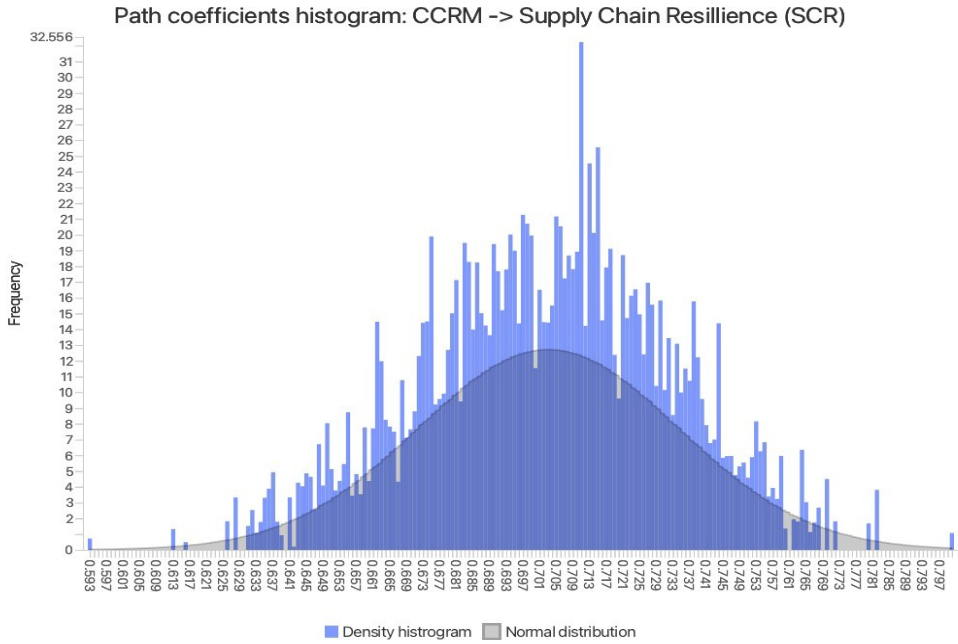

Figure2showntheDistributionofbootstrappedpathcoefficientsfortherelationshipbetween Collaborative Cyber Risk Management (CCRM) and Supply Chain Resilience (SCR).

For CD → CCRM, figure 3 shows the peak of moderate positive correlation at 0.209. The distribution is bell-shaped with 95% confidence limits between 0.127 and 0.298 which are statisticallydifferentasshowninfigure3.Althoughtheeffectwasweakerthanotherrelationships, itimpliesthatthelargercommunicationdiversity(differentchannelsandstylesofcommunication used) positively impacts cyber risk management.

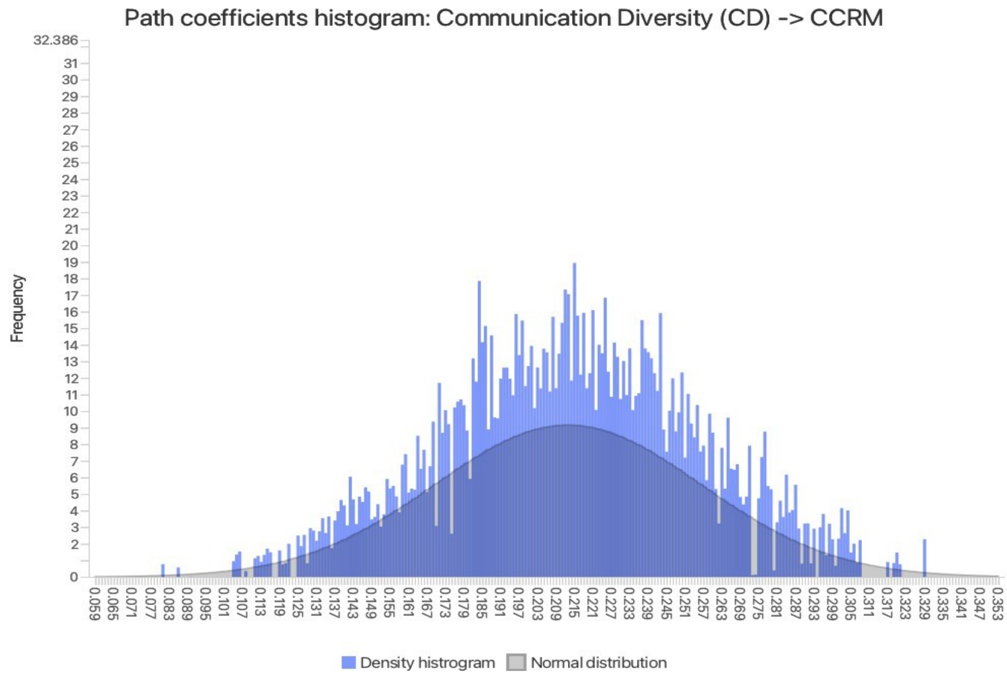

Figure3representtheDistributionofbootstrappedpathcoefficientsfortherelationshipbetween Communication Diversity (CD) and Collaborative Cyber Risk Management (CCRM).

The RD → CCRM histogram is very much concentrated in a symmetric distribution and located at0.341suggestingmerelymoderatepositiveeffectasseeninfigure4.Relationaldiversity— networks, collaboration relationships and partnerships—is a very highly statistically significant and reliable denominator of an effective cyber risk management regime in supply chains (CI = 0.243–0.430).

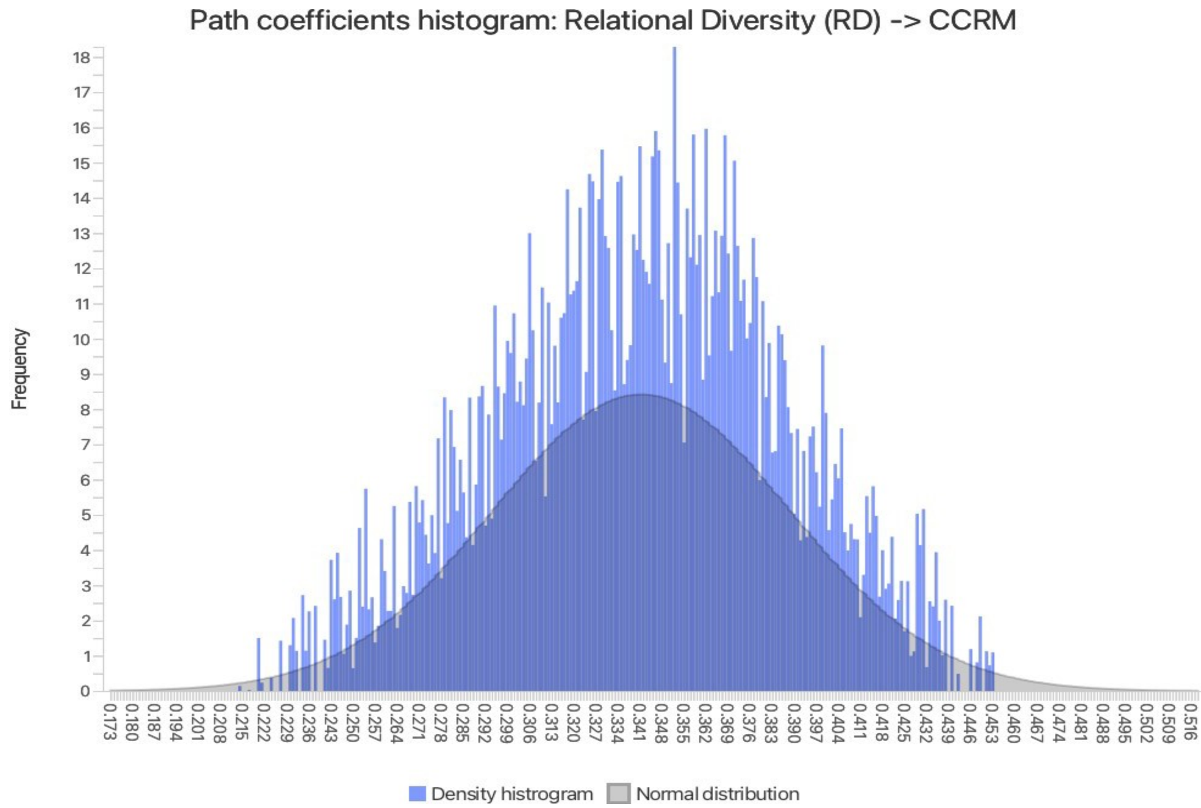

Figure4showstheDistributionofbootstrappedpathcoefficientsfortherelationshipbetween Relational Diversity (RD) and CCRM

TheroleofTD→CCRMissomewhatstronger,thecoefficientbeingabout0.427.Thedistribution isnear-normal,andtheconfidenceinterval(0.339,0.510)continuestoshrinksuggestingconsistent performance as well as a time-stable and statistically significant effect of election timing on vote shares. This is evidence that digital diversity in terms of using and integrating various technologies/systems is an essential enabler for improving collaborative cyber risk management capacities. The interrelationships among the variables in the model are statistically significant as indicatedby(T-statistics>(1.96))e.g.,22.325forCCRM→SCRandP-value=0.000,indicating that the results are not due to random fluctuations.Taken together, the study conveys that CCRM is an indispensable enabler for Supply Chain Resilience and technological, relational and communicationdiversitiesmediatetoimprovetheroleofCCRMtherebyofferingstrongsolidarity and robustness of model linkage.

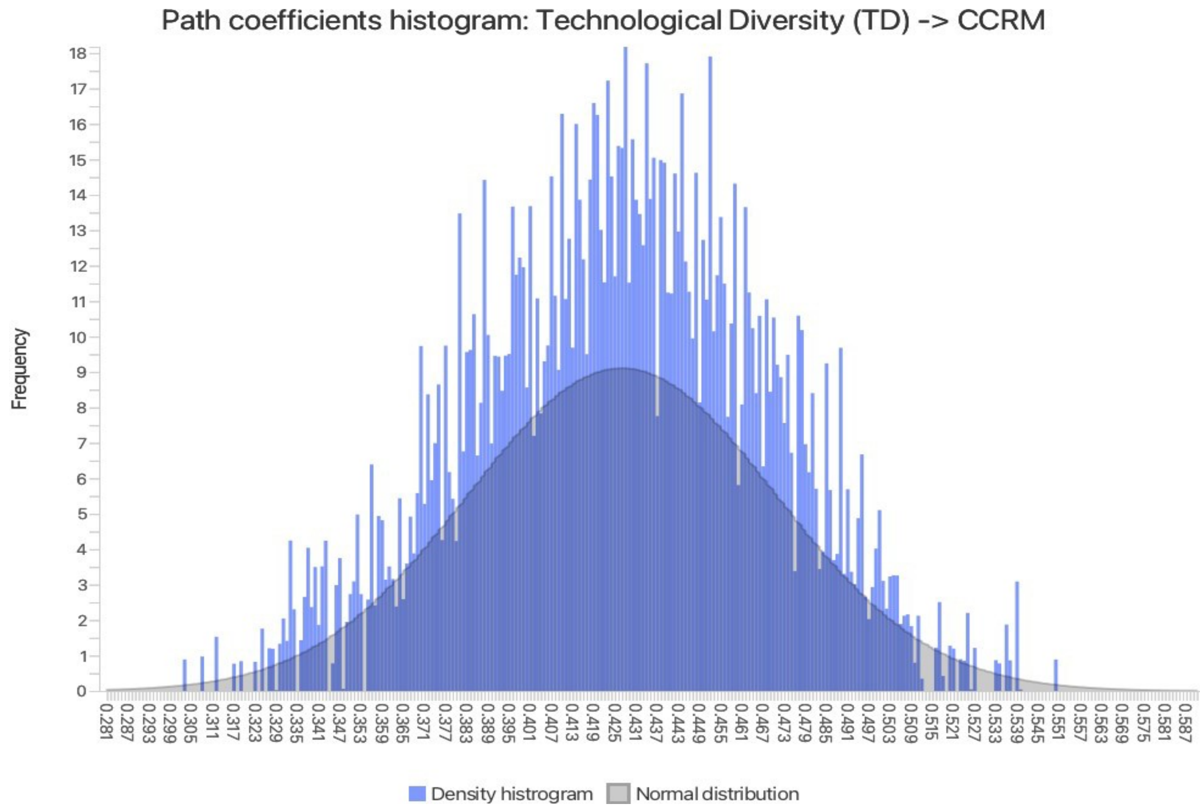

Figure5representtheDistributionofbootstrappedpathcoefficientsfortherelationshipbetween TD and CCRM.

4.2 IndirectEffectsonSupplyChain Resilience

Figure 6 shows histograms of indirect effects from each diversity factor (Communication, Relational andTechnological) to SCR gives an overall picture of the distribution of total indirect effectfromthesefactors.TheseimpactsarefacilitatedbyCCriskmanagement.Foreachhistogram is superimposed the normal distribution corresponding how these indirect effect values are distributedacrossthesimulations.FromCDtoSCR,theindirecteffectismoderatepositiveaswell accordingtothehistogram.Thenormaldistribution-basedpathcoefficientbubblingaround0.147 demonstrates that the model has a fair stability in describing system relationship under all simulations.The95%confidenceintervaloftheindirecteffectbasedonthisE(0.088,0.210)does not include zero. Moreover, the bias-corrected confidence interval ranging from 0.080 to 0.203 further confirms that communication diversity has a positive effect on supply chain resilience through CCRM.

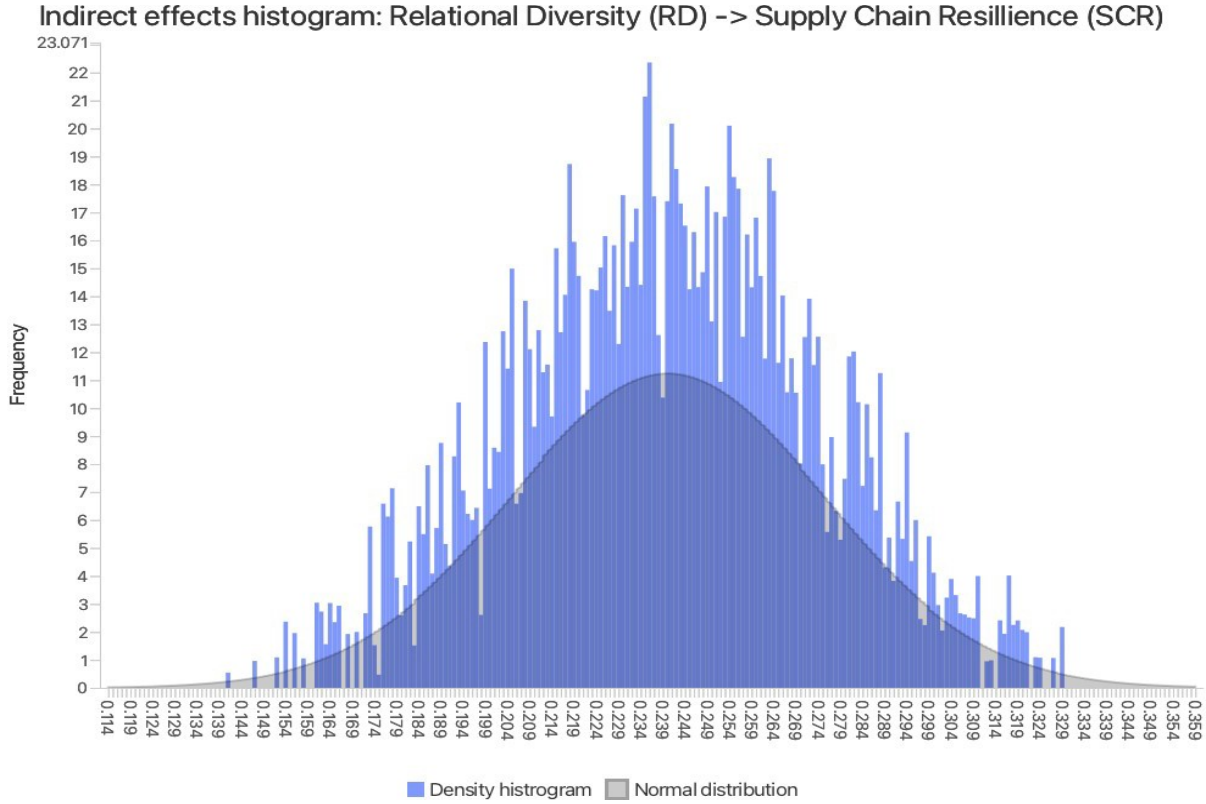

Figure 6 also shows the Distribution of bootstrapped indirect effects for the relationship between RelationalDiversity(RD)andSupplyChainResilience(SCR)mediatedbyCollaborative Cyber RiskManagement(CCRM).

Similarly,theindirectimpactofRDonSCRisshownbyfigure7almostexactlyfollowinganormal distributioncurve.Thepathcoefficientofthismediatoreffectis0.239,suggestingamoderateand relatively strong positive influence on SCR.The confidence interval is between 0.171 and 0.309, further confirming its statistical significance effect.The bias-corrected confidence interval of 0.168 to 0.306 also validates the results, which suggest that relational diversity is also critical in improving supply chain resilience through effective CCRM.

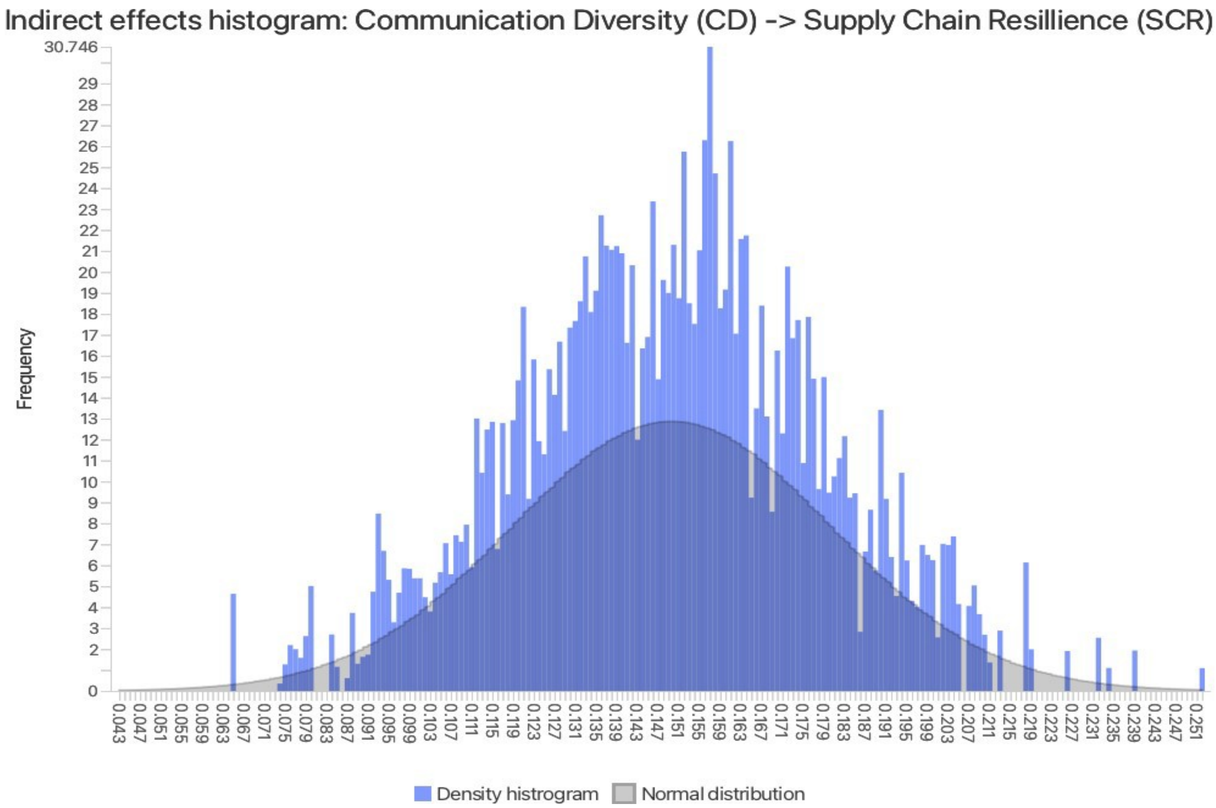

Figure7DistributionofbootstrappedindirecteffectsfortherelationshipbetweenCDandSCR mediated by CCRM

WithrespecttoTD,thehistogrampresentsamoreintenseindirecteffectonSCRwhencompared with others diversity factor (0.300) as seen in figure 8. The data is well fitted by the normal distribution curve, arguing for significant robustness of this relationship.The confidence interval fortheindirecteffectofTDonSCRliesbetween0.232and0.369,whichmeansthatthisisahighly significant influence. The fact that the bias-corrected value [CI] of 0.230 and 0.367 lies between itself further supports this finding indicating that technological diversity significantly promotes supply chain resilience through CCRM.

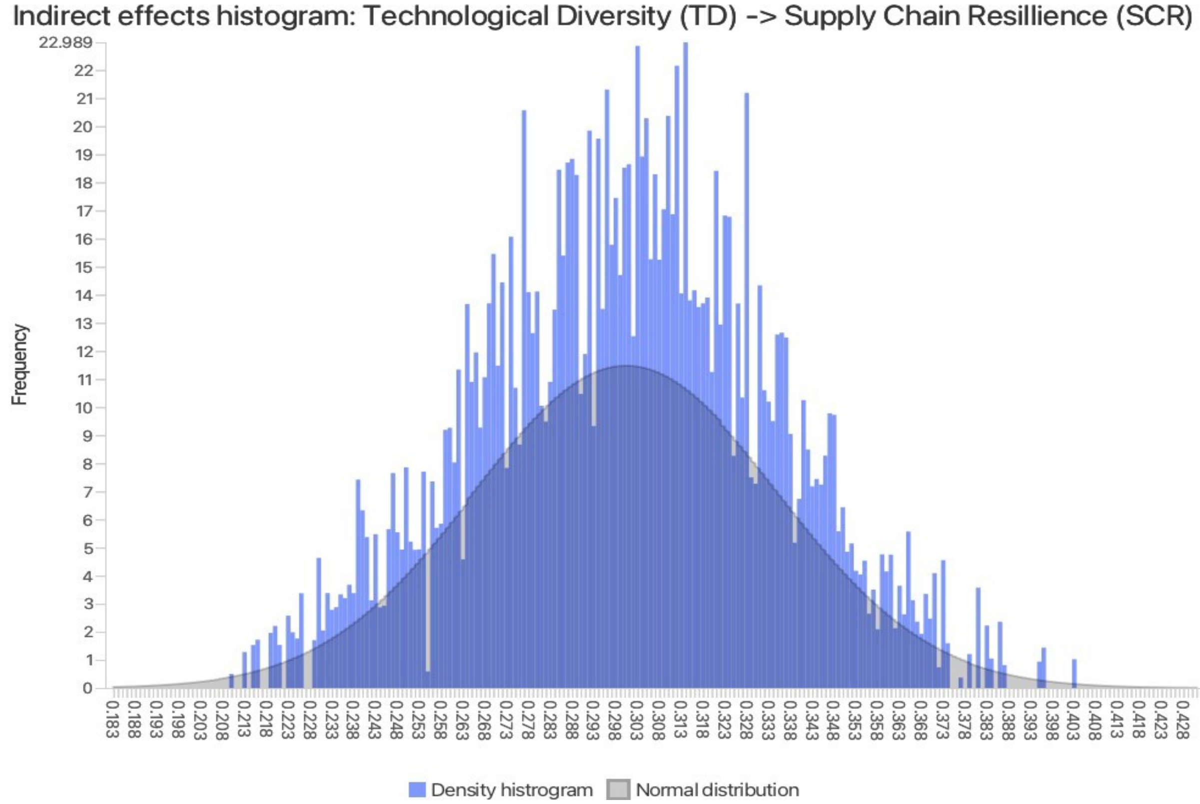

Figure8FigureX.DistributionofbootstrappedindirecteffectsfortherelationshipbetweenTD and SCR mediated by CCRM

4.3 TotalIndirect Effects

TheoverallindirecteffectsofCD,RDandTDonSCRareoutlinedinthetablebelow.Theoriginal Sherlockindirecteffectsare0.147,0.239and0.300respectively.Alltheseeffectsarestatistically significant with 0.000 p-value which establishes that every diversity factor enhances indirectly supply chain resilience via its effect on CCRM. The confidence intervals of these total indirect effects, for example the interval of 0.088 to 0.210 in CD -> SCR, also reinforce the strength and power of this result. Also, the bias-corrected confidence intervals are similar to the original intervals, indicating that the indirect effects are significant and reliable.

4.4 SpecificIndirectEffects

The direct effects of individual aspects of diversity on CCRM and the consequent effect on SCR are also considered. These mediating effects show the mediating mechanism of CCRM, which means that CCRM has an important role in the transformation of diversity factors to an improved supplychainresilience.ThesignificantindirecteffectsobservedforCD->CCRM->SCR,RD>

CCRM -> SCR, and TD -> CCRM -SCR indicate that the results are statistically significant and stable in terms of consistency on account of confidence intervals.

Table5Totalindirecteffects

	Original sample(O)	Sample mean (M)	Standard deviation (STDEV)	Tstatistics (|O/STDEV|)	P values
CommunicationDiversity(CD) ->SupplyChainResillience (SCR)	0.147	0.150	0.031	4.729	0.000
RelationalDiversity(RD)-> SupplyChainResillience (SCR)	0.239	0.240	0.035	6.728	0.000
TechnologicalDiversity(TD)> SupplyChainResillience (SCR)	0.300	0.300	0.035	8.618	0.000
Confidenceintervals					
	Original sample(O)	Sample mean (M)	2.5%	97.5%	
CommunicationDiversity(CD) ->SupplyChain Resillience (SCR)	0.147	0.150	0.088	0.210	
RelationalDiversity(RD)-> SupplyChainResillience (SCR)	0.239	0.240	0.171	0.309	
TechnologicalDiversity(TD)> SupplyChainResillience (SCR)	0.300	0.300	0.232	0.369	
Confidenceintervalsbias corrected					
	Original sample(O)	Sample mean (M)	Bias	2.5%	97.5%
CommunicationDiversity(CD) ->SupplyChainResillience (SCR)	0.147	0.150	0.003	0.080	0.203
RelationalDiversity(RD)-> SupplyChainResillience (SCR)	0.239	0.240	0.001	0.168	0.306
TechnologicalDiversity(TD)> SupplyChainResillience (SCR)	0.300	0.300	0.001	0.230	0.367
Specificindirecteffects					

	Original sample(O)	Sample mean (M)	Standard deviation (STDEV)	Tstatistics (|O/STDEV|)	P values
CommunicationDiversity(CD) ->CCRM-> Supply Chain Resillience(SCR)	0.147	0.150	0.031	4.729	0.000
Relational Diversity (RD) ->CCRM -> Supply Chain Resillience (SCR)	0.239	0.240	0.035	6.728	0.000
TechnologicalDiversity(TD)->CCRM->SupplyChain Resillience (SCR)	0.300	0.300	0.035	8.618	0.000
Confidenceintervals					
	Original sample(O)	Sample mean (M)	2.5%	97.5%	
CommunicationDiversity(CD) ->CCRM->SupplyChain Resillience (SCR)	0.147	0.150	0.088	0.210	
Relational Diversity (RD) ->CCRM -> Supply Chain Resillience(SCR)	0.239	0.240	0.171	0.309	
TechnologicalDiversity(TD)->CCRM->SupplyChain Resillience (SCR)	0.300	0.300	0.232	0.369	
Confidenceintervalsbias corrected					
	Original sample(O)	Sample mean (M)	Bias	2.5%	97.5%
CommunicationDiversity(CD) ->CCRM->SupplyChain Resillience (SCR)	0.147	0.150	0.003	0.080	0.203
Relational Diversity (RD) ->CCRM -> Supply Chain Resillience (SCR)	0.239	0.240	0.001	0.168	0.306
TechnologicalDiversity(TD)->CCRM->SupplyChain Resillience (SCR)	0.300	0.300	0.001	0.230	0.367

4.5 TotalEffectsonSupplyChainResilience(SCR)

The total effects histograms show the aggregated influence of Communication, Relational, Technological on SCR as a result of all mediated pathways. Each histogram is overlayed with a standard distribution, which indicates how the sum of all effects is spread over simulations.

CCRM->SCR(TotalEffect)

Figure9showsthehistogramofCCRM→SCRthatdemonstratessomewhatstrongzeroinfluence (0.701) and its corresponding path coefficient on the face of this histogram. It is also consistent and stable from the normal distribution curve, and this just reflects CCRM’s great success of so enhancingsupplychainresilience.The95%confidenceinterval(0.639–0.762)andbias-corrected interval (0.632–0.756), were good precision and robustness, respectively, demonstrating that maintenance of stability and steadiness of this association in model has been conducted satisfactorily.

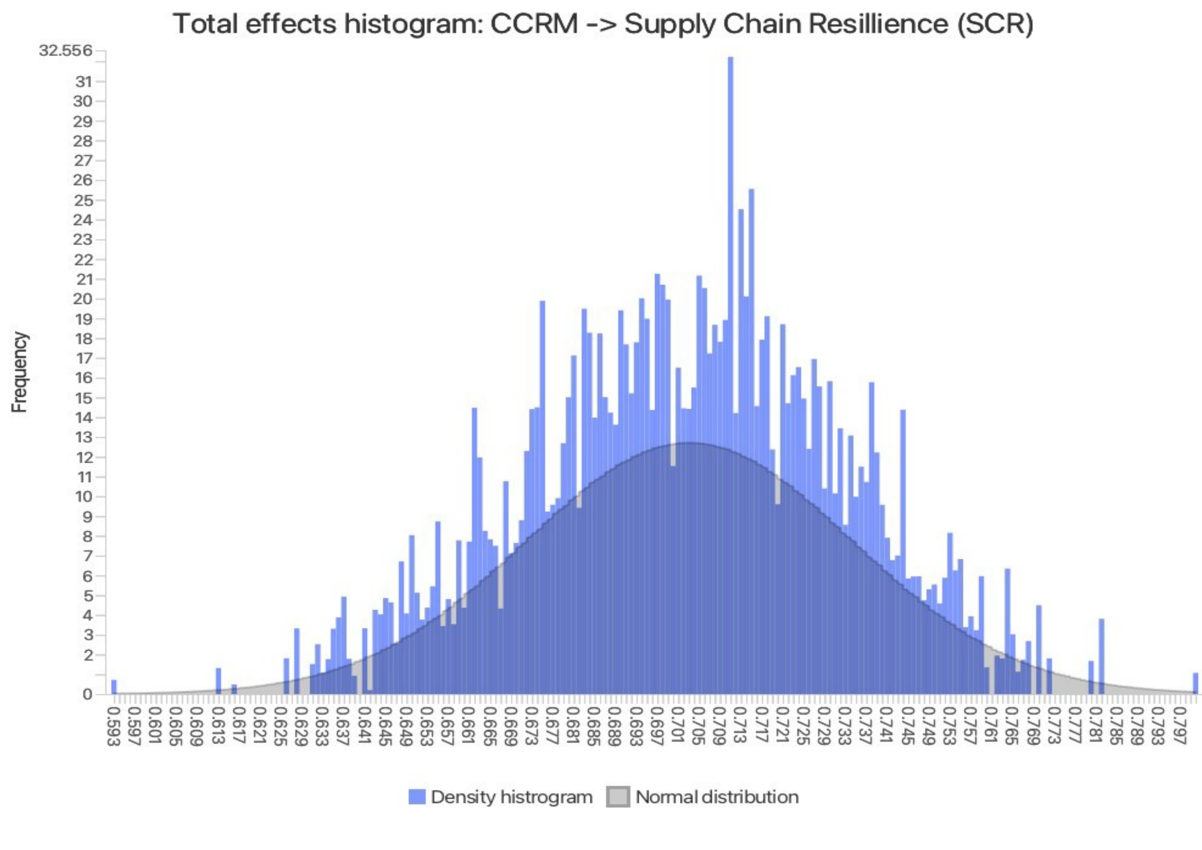

Figure9DistributionofbootstrappedtotaleffectsfortherelationshipbetweenCollaborative Cyber Risk Management (CCRM) and Supply Chain Resilience (SCR).

CommunicationDiversity(CD)->CCRM(TotalEffect)

A comparably less saturated positive impact is observed on the CD to CCRM histogram (Pathunequalto0.209 Coefficient) is shown in figure 10. The distribution was well approximated withthenormalcurveuntilits95%confidenceintervalwidthofbetween0.127and0.298wasless than that, demonstrating statistical significance. This bias-corrected interval (0.117, 0.290) provides additional assurance that the effect is reliable.

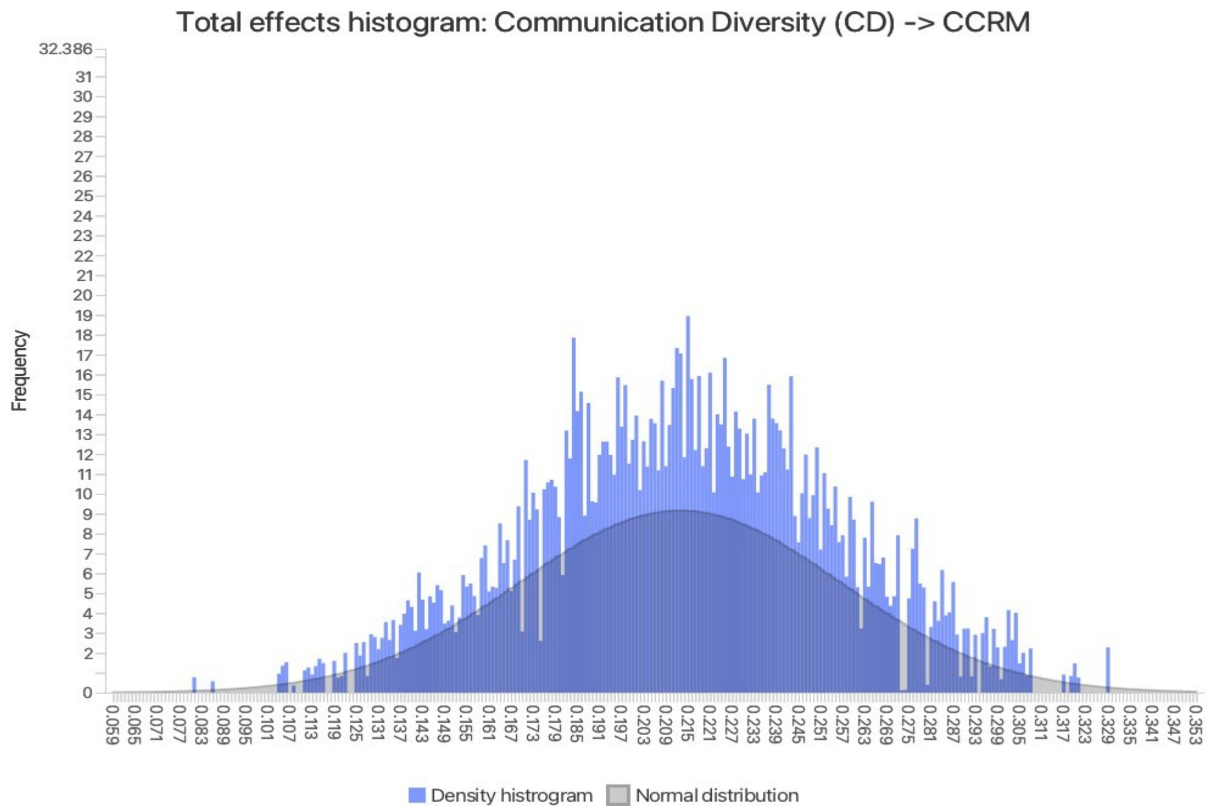

Figure10showstheDistributionofbootstrappedtotaleffectsfortherelationshipbetween Communication Diversity (CD) and Collaborative Cyber Risk Management (CCRM).

CommunicationDiversity(CD)->SCR(TotalEffect)

The moderating effect of Communication Diversity on SCR is summarized by the figure 11 that showsapathcoefficientof0.147,suggestingmoderatebutpositiveside-bandwidthindirecteffect. The 95% confidence intervals for this effect (from 0.088 to 0.210) and the bias-corrected confidence interval (from 0.080 up to.203) confirm that this indirect effect is indeed statistically significant, in line with a mediation of communication diversity between networks structural embeddedness and resilience.

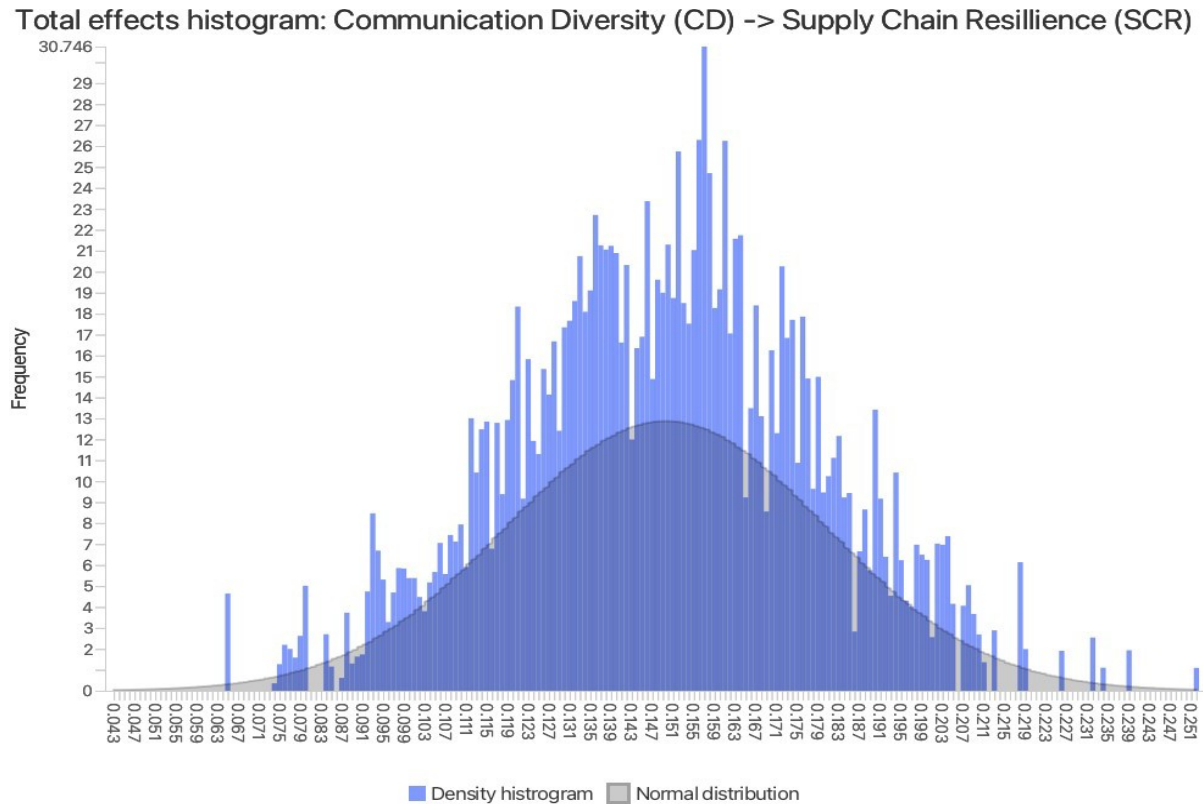

Figure11DistributionofbootstrappedtotaleffectsfortherelationshipbetweenCommunication Diversity (CD) and Supply Chain Resilience (SCR).

RelationalDiversity(RD)->CCRM(TotalEffect)

The RD histogram to CCRM is a moderate positive relationship and the path coefficient is bouncingnear0.1(Thiscoefficientisaround0.341)asgiveninfigure12.Thistrendisalsostable with a good fit normal distribution. The confidence interval on this effect size (0.255 to 0.5) is statistically significant, and the bootstrapped bias-corrected interval is even stronger (from 0.313 to.549).

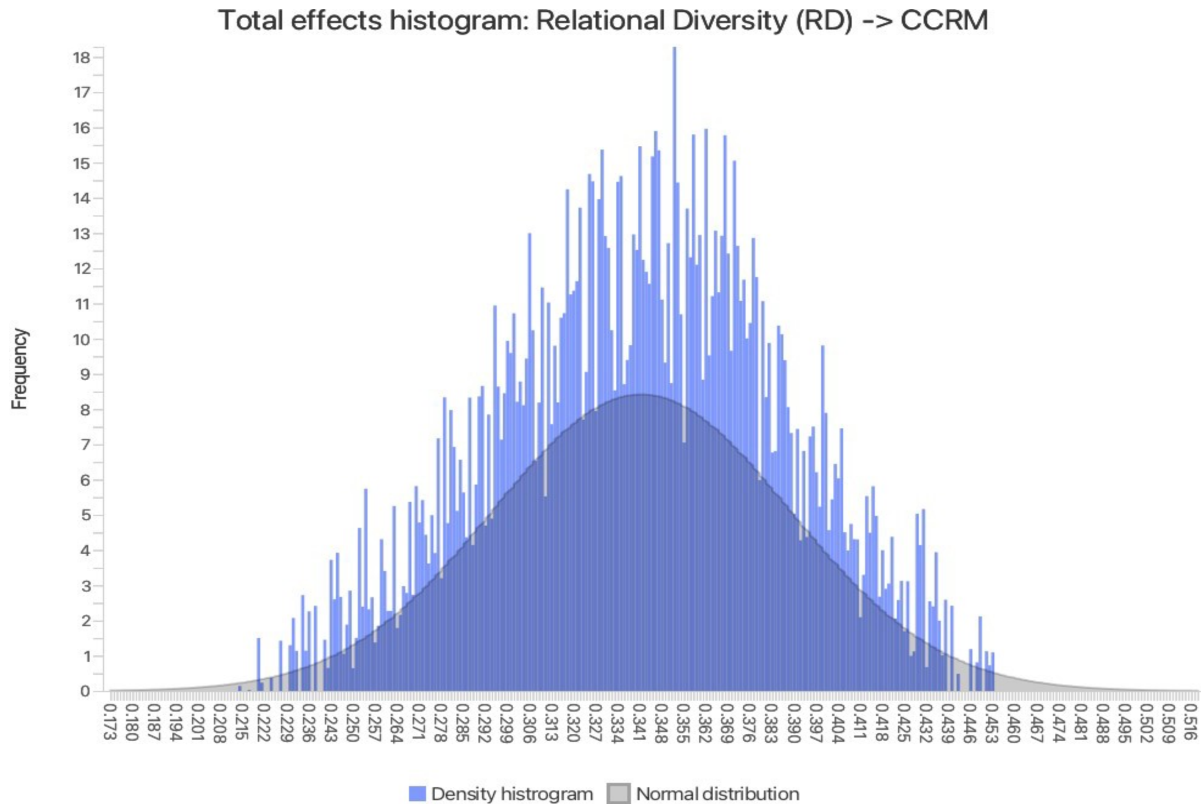

Figure12Distributionofbootstrappedtotaleffectsfortherelationshipbetween Relational Diversity (RD) and Collaborative Cyber Risk Management (CCRM).

RelationalDiversity(RD)->SCR(TotalEffect)

Figure12showsthepathcoefficientofthedirectimpactfromRelationalDiversitytoSCRis 0.239. This normal distribution of the total effect is supported by the confidence interval (0.171, 0.309), which means that relational diversity correlates with significant improvements in supply chainresilience.Thebias-correctedconfidenceinterval(0.168-0.306)supportsthevalidityofthis effect, too.

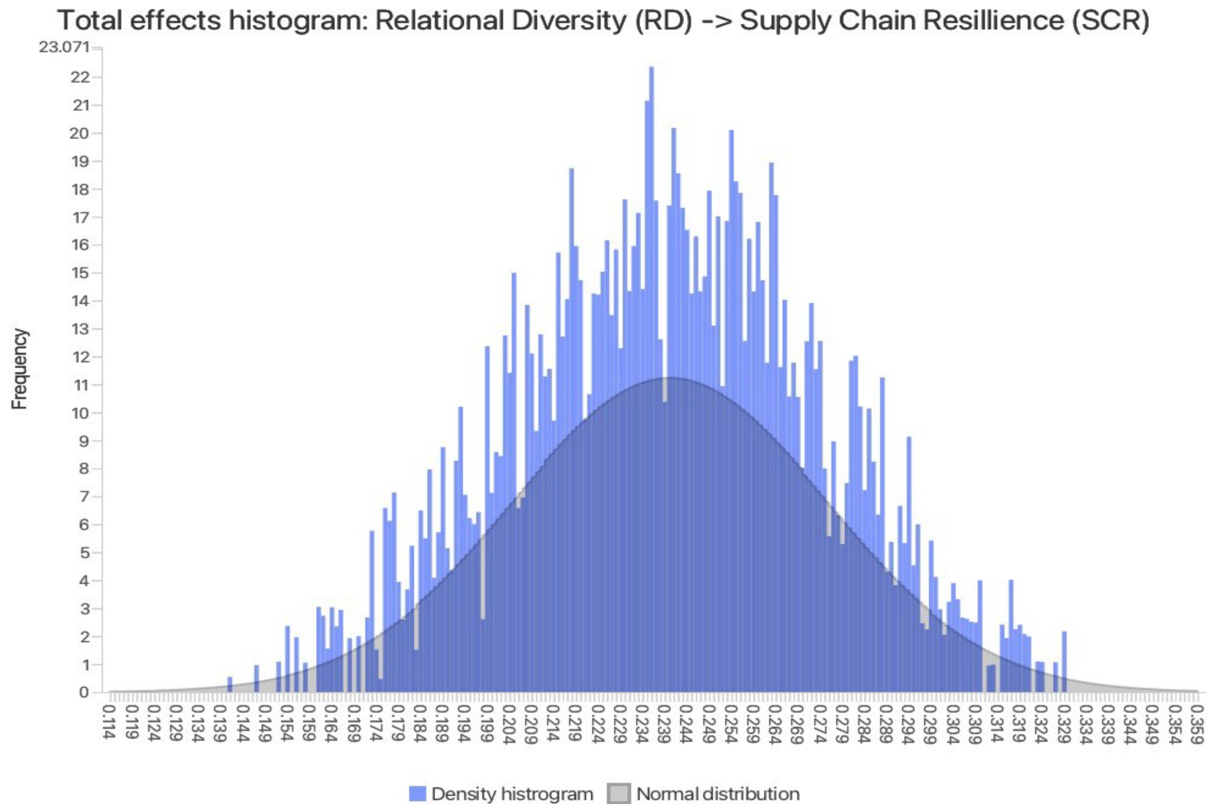

Figure13DistributionofbootstrappedtotaleffectsfortherelationshipbetweenRelational Diversity (RD) and Supply Chain Resilience (SCR).

TechnologicalDiversity(TD)->CCRM(TotalEffect)

RegardingTDtoCCRM,thefigure14showsstrongandpositiveeffectwithpathcoefficientof 0.427 that means technological diversity has got a significant role in improving cyber risk management. The confidence interval of which is from 0.340-0.510, namely technological diversityhasapositiveeffectonCCRMalwaysandthebias-correctedconfidenceintervals(from 339-0.510) further suggest that our result is robust as well.

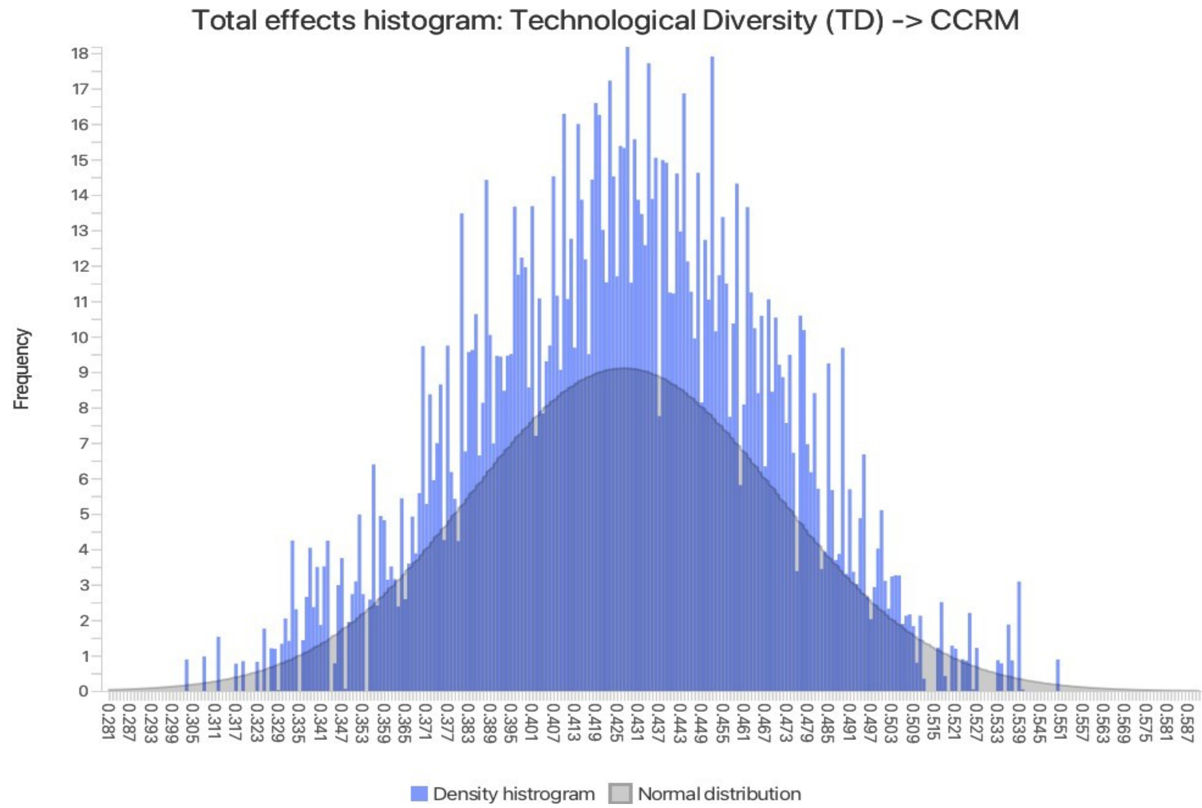

Figure14representDistributionofbootstrappedtotaleffectsfortherelationshipbetweenTDand CCRM

TechnologicalDiversity(TD)->SCR(TotalEffect)

The net impact ofTechnological Diversity on SCR depicted in figure 15 path coefficient is 0.300 whichshowsastrongpositiverelation.Theconfidenceintervalofthistotaleffectisfrom0.232to 0.369, and the bias-corrected interval is from 0.230 to 0.367, which means that technological diversity significantly improves supply chain resilience through CCRM.

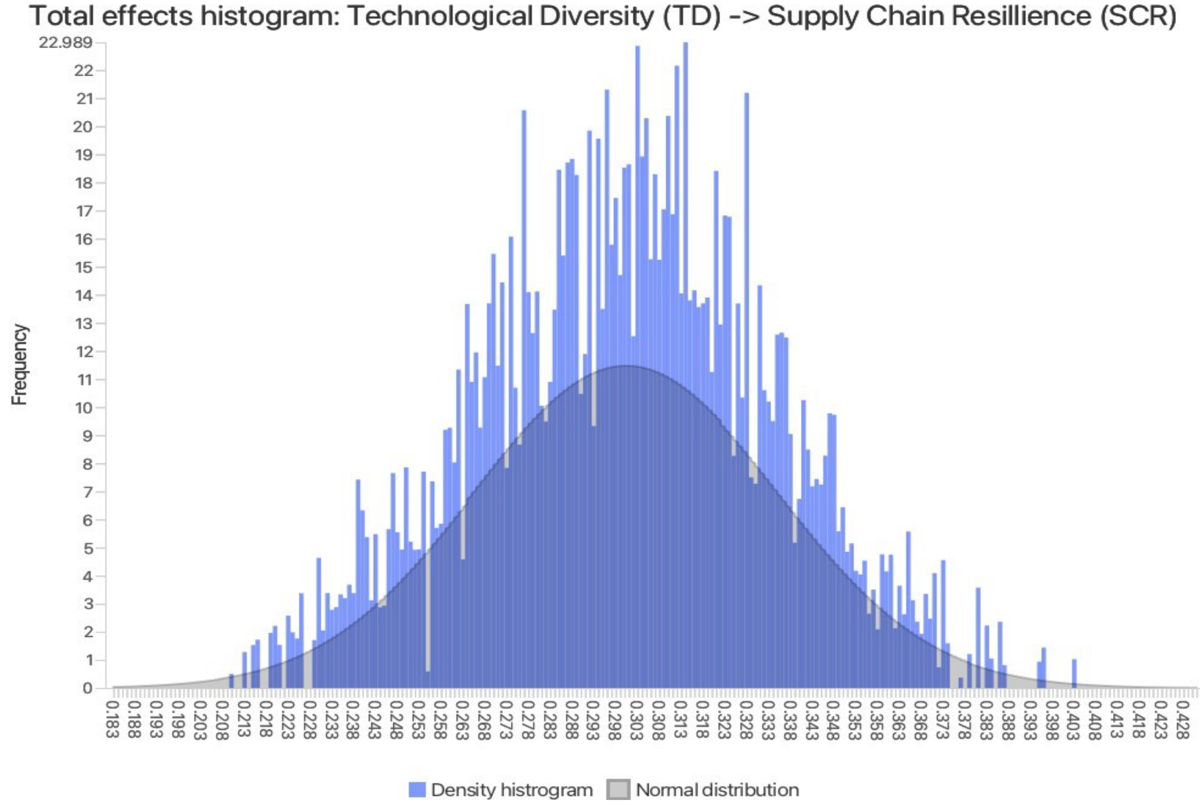

Figure15FigureX.Distributionofbootstrappedtotaleffectsfortherelationshipbetween Technological Diversity (TD) and Supply Chain Resilience (SCR).

4.6 ExplanationofOuterWeightsandPathCoefficientsintheResults

Figure16showsthedistributionofouterweightsindifferentrelationsrepresentedbythestructural model and provide information on consistency, central tendency, and spread of data for each construct. In general, all the histograms show a near normal distribution with prominent peaks at the center indicating that the relationship of model is stable and not highly variable or skewed. This points to high measurement reliability and stability across the sample of observation.

ThefirstgroupofhistogramsarelabelledCCRM1←CCRM,CCRM2←CCRMAndCCRM3 ← CCRM showing the connections between the indicators and Collaborative Cyber Risk Management (CCRM). Both distributions are rather narrow, especially for CCRM1 and CCRM2 whose peaks range between 0.240-0.255. This tight clustering is indicative of high internal consistency and stability across repeated bootstrap samples. Slightly wider spread of CCRM3 ← CCRMisobserved(between0.235–0.260)impliesamildvariationwithprevalenceandatthe sametimepreservesnormalshapesymmetryaboutthedirection,indicatingsoundnessof relationship between latent construct and its indicator items.

The histograms of CCRM4 ← CCRM and CCRM5←CCRM behave similarly with peaks at 0.240–0.245. Indeed, as the values 0.225-0.260 in the table show, they are very close, which are supportedbylowdispersionsofdata(seealsosupportingevidenceofinternalconsistencyfor CCRMconcept).Specifically,therangeofCCRM4appearstobesomewhatlessthanthatof CCRM5,andthisindicatesthatintermsofcontributiontoconstructvariance,itisratherCCRM5 providesstrongerfluctuationatprettyconsistentvaluesforeachperson.Sofar,theapplicationof independentsamplesservestosomeextendasapotentialproofforrobustnessaswellasfor validity of measurement model.

An appealing aspect that can be clearly observed from histograms of CD1 ← CD, CD2 ↔ CD, CD3 ↔ CD and CD4←CD is that the variability seems to increase for construct Communication Diversity(CD).Thepathcoefficientsareof0.240to0.365,themaximumvaluesforCD2andCE3 are0,360y0,365respectively.Theseresultsimplythatcommunicationdiversityhaveasignificant impact on CCRM, although the range (0.240–0.375) indicates heterogeneity in how various communication requirements contribute towards collaborative cyber management. This variant illuminates the multi-faceted nature of communicational diversity in that various forms of communication can facilitate and impede only coordination.

ThehistogramsfortheRelationalDiversity(RD)-RD1←RD,RD2←RD,RD3←RDandRD4 ← RDareshowntothedense-Sparsedistributionwithnarrowspreadofcoefficientsintherange 0.286 to 0.334. The highest spike shown at RD4 ← RD (0.334) represents a practically strong effectonCCRM,ofregularandmediumstrength.Thiscloseassociationsuggestsreliabilityofthe finding, and that relational diversity uniformly contributes toward collaboration outcomes.

Finally, the SCR histograms have coefficients between 0.216 and 0.255 with a maximum value (0.255)forSCR1←SCR.Thesearemoderatespreadsofscoresandthesymmetricalnatureofthe distributionsisreflectiveoftheirstabilitybutabitweakerthanthatfoundfordiversityconstructs. In summary, these histograms confirm that the outer weights of the model are well-behaved, statistically stable and contribute to a measurement and structural sound model.

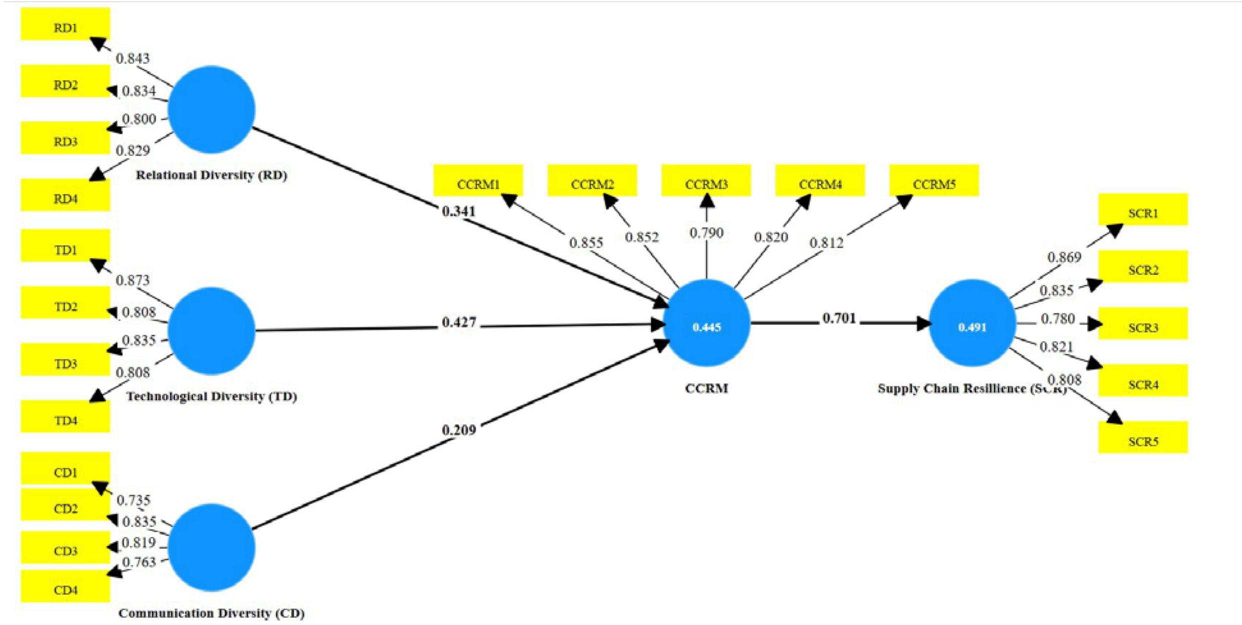

Figure16StructuralEquationModelShowingtheMediatingRoleofCollaborativeCyberRisk Management (CCRM) Between Supply Chain Diversity Dimensions and Supply Chain Resilience

4.7 StatisticalSignificanceofPathCoefficients

Statisticalanalysisoftheouter weightededgesshowsthatvariablehassignificantrelationshipby T-value and P- value.All paths show T-values higher than 20, indicating also highly significant relationships. What is more, P values are all 0.000 and the results seem to be robust in these findings. Such very low p-values are evidence that these observed patterns are not just due to chance (random variation in the relationship between the numbers).

4.8 ConfidenceIntervals

Confidence intervals further reinforce the robustness of the findings. For each outer weight the intervals for sample means are small signaling, very good estimates of path coefficients. For example,theconfidenceintervalforrelationshipCCRM1<-CCRMis(0.2360.274),whichadded these studies support path coefficient estimates of accuracy by 0.254. Similarly, the confidence intervalsofCD-on-CCRMcoefficientsarequitenarrow:Asexample,whichhaveCD2<−CDin [0.258, 0.481], and so on, as well as CD3 <−CD in (0.2640176, 0.4925934). These intervals confirmthatthestabilityonthesamplelevel,observedineffectsizesofcommunicationdiversity effects.Plus,thebias-correctedconfidenceintervalsgivemoreaccurateestimates:Thecoefficientwise confidence intervals have become slightly narrower meaning that the corrections work and subtract from potential sample biases.

4.9 AnalysisofOuterWeightsforRelationalDiversity(RD)inSupplyChain Resilience

Finally, histograms of outer loadings from Relational Diversity (RD1–RD4) are also useful crosschecks for distribution and normality of data to understand how relational diversity contributestosupplychainresilience.Andeachhistogramhasalineimage,whichwouldindicate the data have moderate and uniform tendency to be steady. The distribution for RD 1 is highly positively skewed (most values being clumped together around 0.24) indicating substantial moderate effect on relational diversity. RD2 is a bit less peaked and more uniform but still has a peak in the middle at0.26 The data distribution still looks nearly gaussian with slight spread. RD3hasamodeofapproximately0.29,whichmeansthatitcontributesmore:centrallyorheavily influences relational diversity with less variation. But the largest value (0.33) of RD4 is also in terms that for whom the same column, and its intensity by now is still bigger than other columns which means it has more good consistency relationship than these four indicators.The symmetry and peaks at centre for all of these variables agree with normality distribution of data sets along with the outliers' weights. All in all, these results show that all diversity dimensions RD3 and especiallyRD4positivelyaffectedsupplychainresilience,throughuniformlydistributedweights which ensured both reliability of constructs and predictive power in the overall structural model.

4.10 RelationalDiversity(RD1, RD2,RD3,RD4) andOuterWeights

TheouterweightshistogramsofRD1toRD4presentadistributionwhichissymmetricandnormal, thenlettingusconsiderthereliabilityofdata.RegardingRD1,thereisapeakaround0.25andthe frequency gets less thick as higher values leading to stable solution. RD2 and RD3 demonstrate marginally higher means, up to approximately 0.30-0.35 indicating stronger contributions while maintainingfullaccordancewiththelatenttrait.RD4hasadistributionthatfollowsthesametrend as RD3 but with more spread and values not peaking all the way up, suggesting slightly more difference between responses. These perceptions are statistically validated and each of the indicators gives T-values more than 2 p-value '0.000' hence all these indicators are significant. Taken together, these findings demonstrate the significance of each diversity dimension to the model, contributing robustness and supporting the important insight that relational diversity is critical to bolstering CCRM/SCR and integrity of overall framework.

4.11 SupplyChainResilience(SCR1,SCR2, SCR3,SCR4, SCR5)and OuterWeights

ThedistributionsforSCR1–SCR5arebroaderthanrelationaldiversityvariables,suggestinghigher dispersion of outer loadings. SCR1 is a very wide distribution with peak at about 0.25 and some extended tail towards its right, indicating the presence of extreme values. SCR2 shows a higher andstrongerpeakconcentrationaround0.27,thebehavioristhusmorestablewithrespecttosuch relationship of SCR2 with the latent construct. SCR3, SCR4, and SCR5 demonstrate the same trend; whereas the peak of the curve for SCR3 is approximately 0.23 that of SCR5 spreads in a longer range and goes through about 0.29 implying different influence between them. Nevertheless, all SCR measures turn in highly significant results, withT-statistics higher than 20 and p-values of 0.000. This validates that each construct of Supply Chain Resilience in a statistically significant way is contributing the model, indicative for all five measures having enough reliability to explain their underlying factor and being important factors capturing the overall performance of resilience in supply chain system.

4.12 F-SquareValuesAnalysis

Regarding f-square, this metric gives an understanding of how much one latent variable explains the variance in another. In this model, it demonstrates how much diversity indicator explains the effectonSupplyChainResiliencethroughCustomerRelationshipManagement.Thus,CCRM→ SCR has a significantly high f-square and undoubtedly strong and positive influence. In other words, it means the improvement of customer management significantly improves supply dependency and flexibility. Regarding Communication Diversity CD → CCRM, f-square is very small, which means that it has a weak and insubstantial role. This suggests that communication variationshavelittleeffectonimprovedCRM.AsforRelationalDiversityRD→CCRM,itshows a moderate effect, which means it contributes moderately to a better CRM. Therefore, TD → CCRM has a moderate effect, which means it can support CRM performance, but not as much as CRMimpactSCR.Asaresult,themostimportantfactorthatleadstoanincreaseinSupplyChain Resilience is CCRM, which is followed by a moderate contribution of relationships and technological diversity that has a minimal role in Communication.

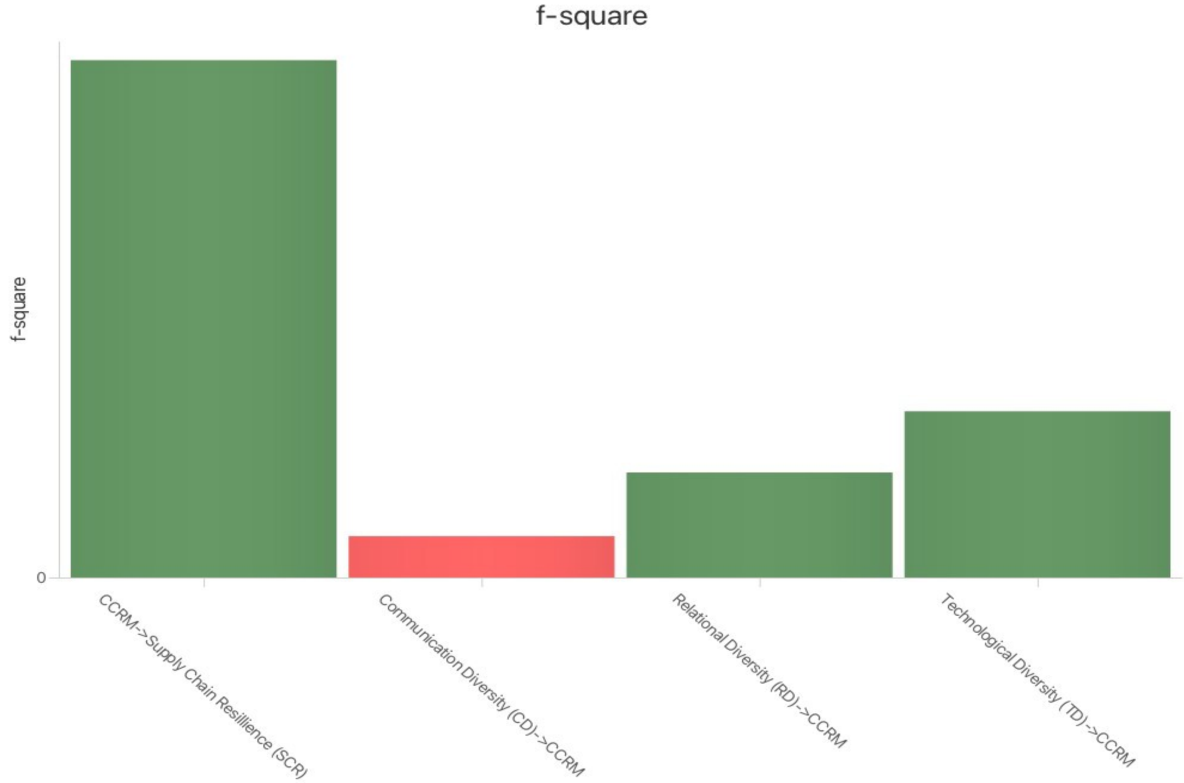

Figure17Effectsize(f²)valuesforstructuralmodelrelationshipsinthePLS-SEManalysis

4.13 Cronbach's Alpha Analysis:

The Cronbach'sAlpha values measure the internal consistency of all constructs, for which higher values close to 1 represent sound reliability. The Cronbach's Alpha indicates excellent internal consistency among all constructs of the model (CCRM, CD, RD, SCR and TD). Reliability is acceptable in CCRM, indicates a good item performance and concept representation. CD also exhibitsgoodreliability,enablingreliablemeasurementofcommunication-relatedvariables.The highscoreforRDreflectstheinternalcorrelationofitemsusedtoassessrelationaldiversity,while SCR shows the resilience measures are trustworthy and valid ones. Likewise, the high alpha coefficientofTDalsoindicatesagoodreliabilityinmeasuringtechnologicaldiversity.Insum,the relatively high Cronbach's Alpha scores for all constructs collectively indicate that the measurement items exhibit adequate internal consistency and reliability, thus validating the data and supporting confidence in overall use of the measurement model used in this analysis.

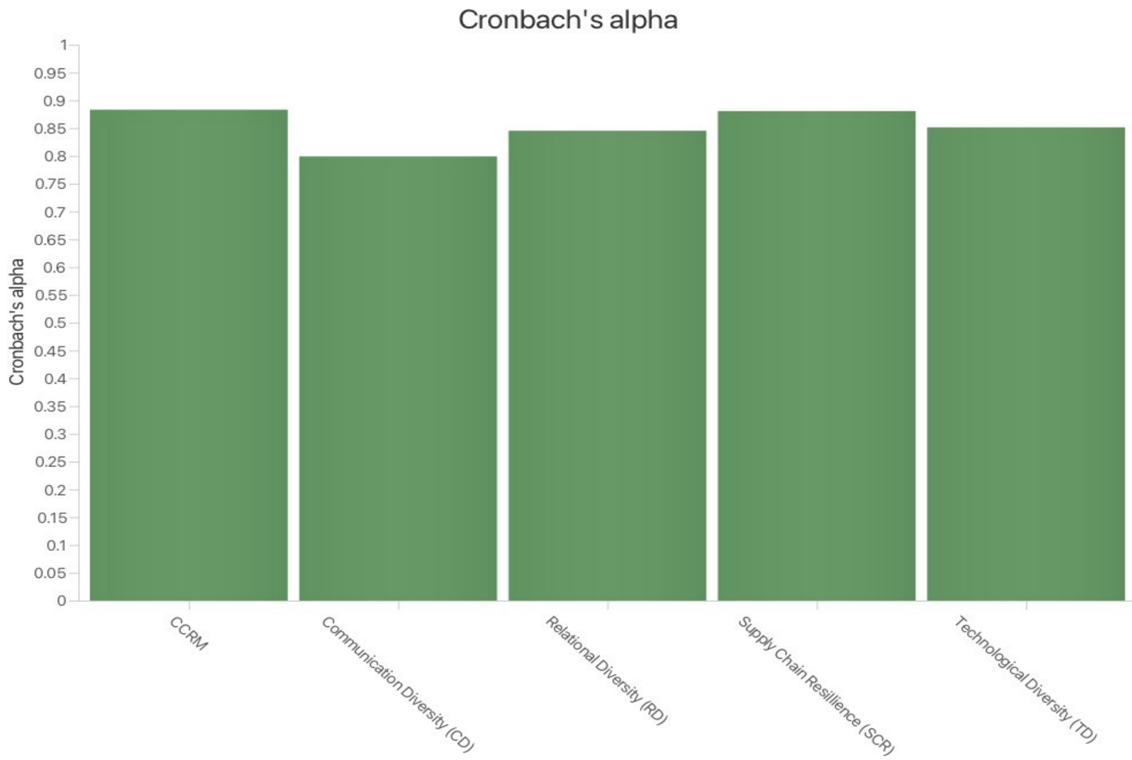

Figure18InternalconsistencyreliabilityofstudyconstructsbasedonCronbach's alpha

4.14 CompositeReliability(rho_a)Analysis:

TheCompositeReliability(rho_a)showstheinternalreliabilityoftheconstructsandscoresgreater than 0.7 indicate a reasonable level of reliability.All constructs in this model are higher than the threshold of 0.7, namely ranges from 0.868 to 0.949 reflecting robust reliability throughout the measurement model. CRM-CCRM indicates the highest rho_a value (0.949), and this suggests very good consistency and high reliability of item correlation. The third dimension is CommunicationDiversity(CD),with0.868indicatingconsistentmeasurementofcommunication items.RDtolls0.906,providingevidencetoitsitemsareequalintervalmeasuresoftheconstruct. Supply Chain Resilience (SCR) has a rho_a = 0.898, indicating reliable inter-item relationships within SCR items. Likewise, Technological Diversity (TD) responds 0.926 indicating a high consistency among its indicators. In general, the relatively strong rho_a among all constructs confirm that the model shows a good internal consistency, i.e., all the constructs are measured without random errors and the items in their respective scales reflect well in terms of what were intended to be included in their measurement frameworks.

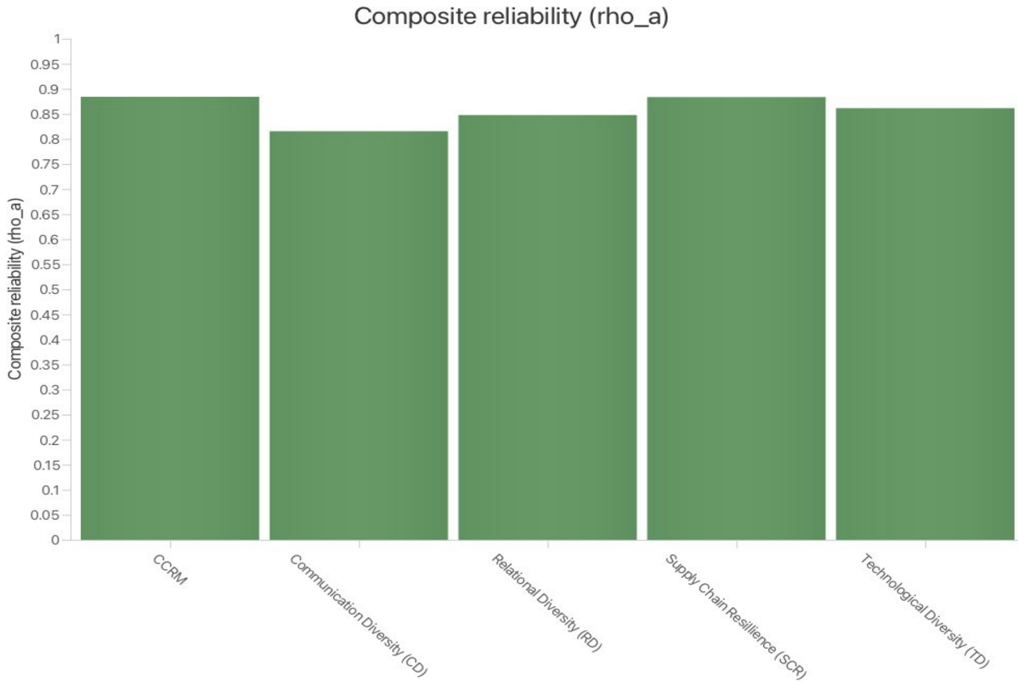

Figure19Compositereliability(ρa)oflatentconstructsinthemeasurement model

4.15 AverageVarianceExtracted(AVE)Analysis:

ConvergentvalidityisevaluatedbymeansoftheAVE,whichrepresentshowmuchvarianceinthe indicatorsisaccountedforbyeachconstruct.AnAVEbelow0.50showsalackofvalidity.Allthe modelconstructsexhibitahighlevelofconvergentvalidityasindicatedbyAVEsthatfallbetween 0.705to0.783.CustomerRelationshipManagementCCRMhasahighAVEvalueof0.755,which meansthatitsindicatorsrepresenttheconstructwell.communicationdiversity(CD)demonstrates anAVE of 0.705, indicating a successful indicator explanation. Relational Diversity (RD) has a verygoodAVEof0.783,whichindicatesthatitsindicatorsexplainmostvarianceintheconstruct. Likewise, SCR has also strongAVE 0.781 and TD close to that value with 0.767 indicating high internalconsistencyaswell.Overall,thesefindingssuggestthatallconstructssatisfythesuggested criterion and indicate that the indicators converge quite well in measuring their corresponding constructs,hencesupplyingstrongconvergentvalidityasameasurementmodelonalldimensions.

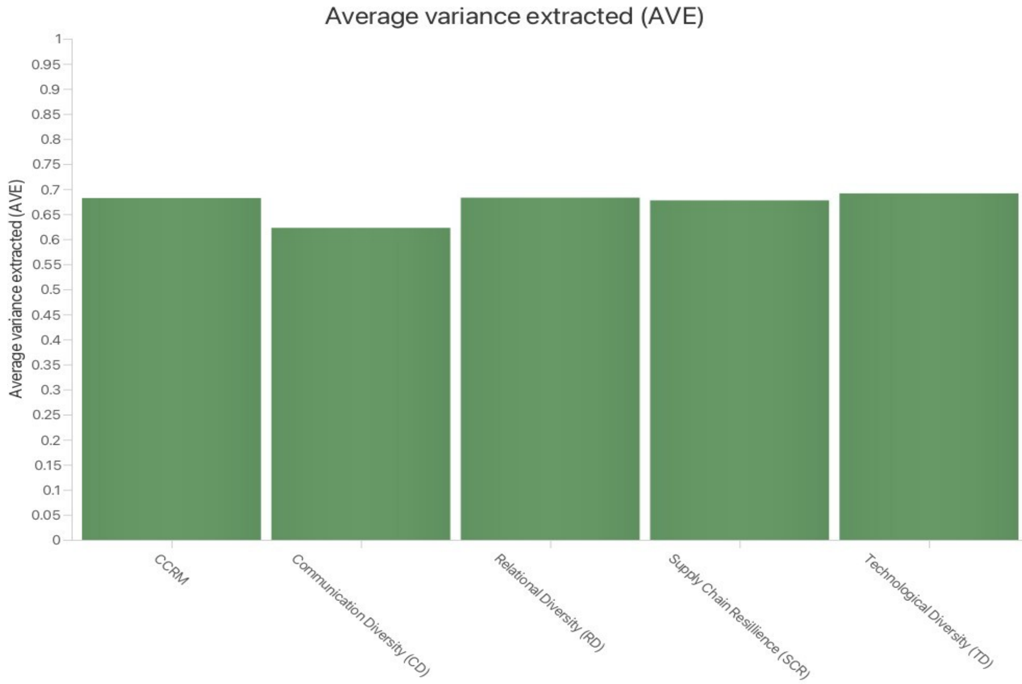

Figure20AverageVarianceExtracted(AVE)valuesforlatentconstructsinthemeasurement model

4.16 Heterotrait-MonotraitRatio(HTMT)Analysis

Discriminant validity, which is the extent to which constructs are different from other constructs, was evaluated through use of HTMT. Values less than 0.85 suggest strong discriminant validity and those above 0.90 indicate overlap. The findings indicate that the majority of constructs have adequate discriminant validity. CD and CCRM (0.574), RD and CD (0.588), and TD with other constructs (0.662—0.768) are all well-discriminated. RD with CCRM (0.841) and TD with SCR (0.874)arejustbelowthecut-off,showingmoderaterelationshipsbutacceptablethough.However, SCR and CCRM have a high HTMT (0.953), indicating poor discriminant validity and potential confoundingbetweenthesetwoconstructs.OtherrelationshipssuchasSRCwithCD(0.762)and SRCwithRD(0.728)arestillwithinacceptablevalues.Overall,thefindingssupporttheempirical distinctivenessofallconstructsexceptforSCRCRMpairthatmayrequirefurtherimprovementor refining.Thisisevidenceoftheconstructvalidityofthemeasurementmodelandsuggeststhatthe constructs largely represent different conceptual dimensions within the model.

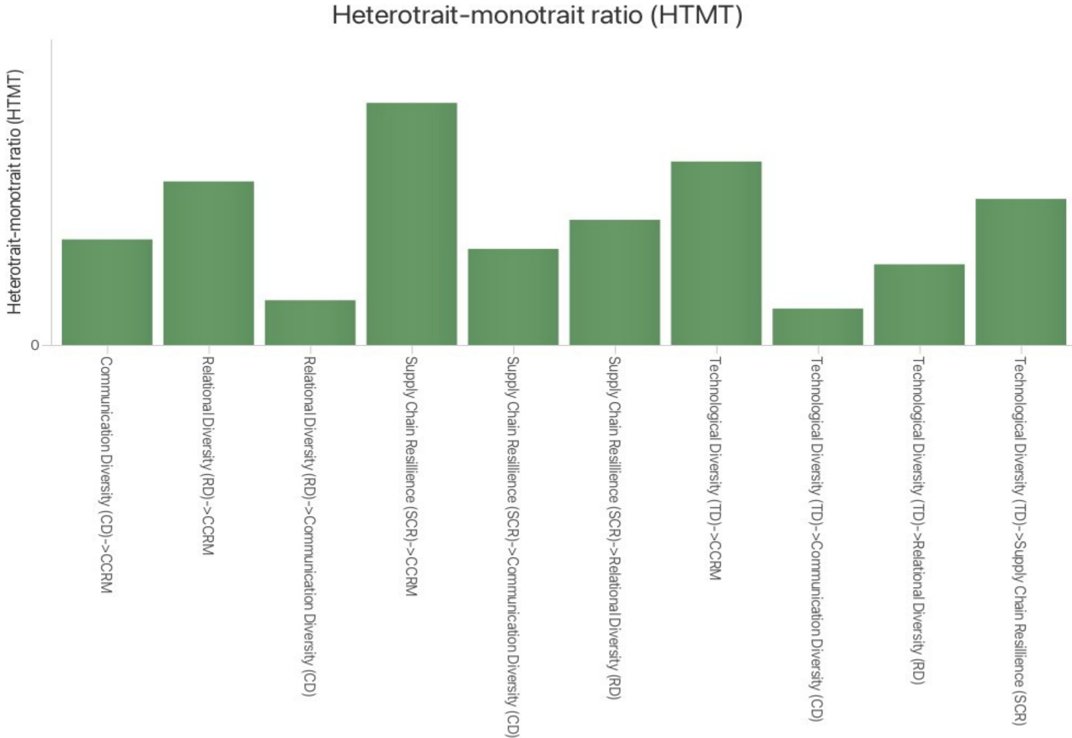

Figure21Heterotrait–Monotrait(HTMT)ratioforassessmentofdiscriminant validity.

CHAPTER 5Discussion

The results of this research demonstrate significant correlations among relational, technological and communication diversity, and supply chain resilience. This suggests that relational diversity can have a disproportionately high emphasis on resilience as it promotes collaboration, trust and knowledge sharing among supply chain partners. It is consistent with prior research that demonstratedavarietyofrelationshipsinsupplychainmayimproveflexibilityandresponsiveness at time of disruptions (Lau et al., 2021). Indeed, as businesses work closely with culturally and organisationally diverse partners, they become more capable of reacting to crises in new ways, solution-based thinking, and greater flexibility.

Technologydiversityhasalsobeendemonstratedtoenhanceresiliencebutismorecomplex.Firms with a diverse technological footprint, in the form of using or not using ERP systems, AI and blockchain applications appear to be more willing adopters to disturbances. Such flexibility is of particular importance when these technologies are efficiently implemented into supply chain operations.Butthisresearchalsoilluminatesthattechnologicaldiversitycanresultin interoperability difficulties which can undermine the benefits of technical diversity, especially when not managed adequately. It is friction between such systems, that e.g., may introduce inefficiencies or time-lags in response to events as they unfold (B.Yang et al., 2024).

Diversity of communication (in multinational environments with multilingual and multicultural teams) is a crucial factor of SC resilience.The results highlight the need for clear communication andtheuseofstandardizedreportingmechanismstofacilitateinformationtransmissionthroughout all supply chain echelons. The risks are increased and response is unduly delayed with miscommunications or late messages in a crisis. This is consistent with previous studies that highlighted the significance of good communication to prevent any misinterpretations and operational delays (Palit et al., 2022).

The findings of the research effectively provide answers to the research questions by establishing that relational diversity and technological diversity have a positive significant impact on supply chain resilience. RQ1 questioned what the impact of relational diversity is on resilience, and the findings demonstrate that companies with diverse relationships throughout their supply networks are more resilient firms. And to RQ2, regarding the effect of technological diversity, is also addressed (concluding that technological diversity increases adaptability while imposing integrationdemands).ForRO1,findingsfromthestudyconfirmthatrelationaldiversityincreases trustandcooperationwhichintheirturncontributedirectlytoresilience.RO2istestedbyproving thepositivecorrelationbetweendiversityoftechnologyandcommunication,andhowitcanreduce response time to supply chain disruption.

Most of these results agree with those of Lau et al. (2021) and Palit et al. (2022) that relational diversityenhancesresiliencethroughcollaborationandtrust.Thisinvestigationcontrastswiththat ofKhuranaetal.(2022)whosuggestedthatdiversificationoftechnologybringsmoreinefficiency. In contrast, we have point out that the diversity of technology can also improve supply chain flexibility and swiftness when incorporated properly during disruption.

TheoreticalContributions:Atatheoricallevel,thisresearchprovidesstrongerempiricalevidence for RBV and DCT since it has demonstrated that relational and technological diversification can bevaluableresourcestobuildresilience.ItalsocomplementsDCTbyshowingthewaysinwhich a firm can adjust and revitalize its processes on-the-fly to address disruptions.

Theoretical and Practical Implications:The findings of this research have practical values for the supply chain manager particularly that in multi-national firms. Relational diversity (companies working across cultural borders and forming great partnerships). Managers should also thoughtfully combine various technologies to improve operational flexibility while still enabling system intermember. Finally, companies should invest in training for their teams on how to communicateacrossdiverselanguagesandculturesastokeepoperationsrunningsmoothlywhen disaster strikes.

Conclusion

Thisstudyexaminestheeffectsofrelationaldiversity,technologicaldiversity,andcommunication diversity on supply chain resilience, and to investigate the mediating role of CCRM among multinational corporations operating in Pakistan. The core objective was to determine whether diversity within global supply chains strengthens organizational resilience and to assess how collaborativecybersecuritypracticesconvertdiversity-inducedcomplexityintoresiliencecapacity.

The responses were collected from manager and professionals employed in multinational companies running their business operation throughout Pakistan by a structured questionnaire. Reliabilityandconstructvaliditywereassessedusing Cronbach'sAlpha,factorloadings,AVEand discriminant validity tests. Hypotheses testing were performed through correlation analysis, regressionmodeling(standardapproach)andPLSinstudyingtheStructuralEquationModelling. This multi-level approach enabled statistical sophistication alongside theoretical coherence.

The results indicated that relational diversity, technology diversity and communication diversity haveastatisticallysignificantandpositiveimpactontheresilienceofsupplychain.Organizations withrobustcross-cultural,technological,andcommunicationrelationshipsweremorepreparedto anticipatebreakages,absorbdisruptions,andquicklyrebound.Ofthese,communicationdiversity was seen as the most significant factor signifying the importance of clarity, shared understanding and communication in culturally diverse supply chains.

The findings also showed that collaborative cyber risk management mediated the relationship between diversity and resilience substantially. This suggests that diversity in and of itself is not necessarily a source of resilience, but organized cooperation (in cyber risk identification, joint planningforresponsecoordinationandsharedsecurityresponsibility)canhavethepotentialto makesynergisticuseofsuchdifferencesassourcesofresilience.Bytheeffectivemanagementof CCRM practices, firms could turn heterogeneity not to operative risk but strategic advantage.

Thestudyalsosupportedtheapplicabilityoftheproposedtheoreticalsynthesisbetween RBVand DCT. RBV explains the strategic importance of diversity as an organizational resource, whereas DCT defines how resilience comes from the ongoing re-combination of such resources. Collectively, they furnished a robust theoretical basis for the way in which MNFs utilize both diversity and collaboration to achieve supply chain resilience amid unpredictability in digital space.

In terms of contribution, the paper provides a major theoretical refinement by placing communication diversity as a fundamental resilience variable, and not only an impediment in language.Empirically,itaddstothebodyofevidencefromPakistan–anemergingeconomywhere research on SCR is under-representation.Theoretically, the results provide practical implications for policy makers, multinational companies and supply chain managers to better understand the need of cross-organizational cybersecurity cooperation and the adoption of digital coordination systems as well as cross-cultural communication strategies.

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