



Daffodil
International
University

Thesis Report

On

**Assessing Trade Competitiveness of E-Business Firms in Bangladesh
Using Porter's Diamond Model Indicators: An Econometric Method and
Multi-Criteria Decision-Making Model Approach**

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This Report is submitted to the Requirement for the Degree of BBA in
Management

Submission Date: 02 January 2025

Letter of Transmittal

Date: 23 December 2024

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Subject: Submission of Thesis Report on Assessing Trade Competitiveness of E-Business in Bangladesh Using Porter’s Diamond Model Indicators: An Econometric Method and Multi-Criteria Decision-Making Model Approach

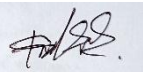
Respected Sir,

I am honoured to submit my thesis report titled “**Assessing Trade Competitiveness of E-Business Firms in Bangladesh Using Porter’s Diamond Model Indicators: An Econometric Method and Multi-Criteria Decision Making Model Approach,**” which is a partial requirement of the **BBA in Management** program at Daffodil International University. This report is based on a comprehensive analysis of the trade competitiveness of Bangladesh’s e-business sector, utilizing Porter’s Diamond Model in conjunction with econometric methods and Multi-Criteria Decision-Making (MCDM) tools.

The report delves into critical aspects such as Internet Penetration Rate (IPR), Online Sales Volume (OSV), and the Number of E-Business Firms (NEF), providing actionable insights into the factors driving trade competitiveness. It highlights the opportunities, challenges, and strategies essential for the growth and sustainability of the e-business sector in Bangladesh. Throughout this academic endeavour, I have adhered to rigorous analytical methods and maintained alignment with the university’s academic standards under your valuable guidance.

I sincerely appreciate the support and encouragement you have extended to me during this process. Your expertise and feedback have been instrumental in shaping this thesis, and I hope it meets your expectations. I look forward to your evaluation and any further recommendations you might have.

Sincerely,



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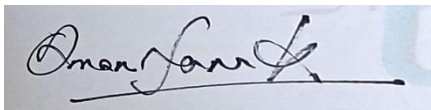
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Certificate of the Supervisor

This is to certify that the thesis report titled “**Assessing Trade Competitiveness of E-Business Firms in Bangladesh Using Porter’s Diamond Model Indicators: An Econometric Method and Multi-Criteria Decision Making Model Approach**” has been prepared by Steven Samuel Bose (Student ID: 201-52-001), a student of the BBA in Management program at Daffodil International University. The report is based on his thesis at Daffodil International University and meets the academic standards of the university. I confirm that the report is original and eligible for submission as a partial requirement of the program.



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Acknowledgement

I would like to express my heartfelt gratitude to my supervisor, **Dr. Omar Faruk Sir**, for his invaluable guidance, constructive feedback, and unwavering support throughout this research. His expertise and encouragement played a pivotal role in the successful completion of this work.

I am also sincerely thankful to **Dr. AKM Mohsin Sir** for his guidance and insightful advice, which greatly enhanced the quality of my research. Their support has been a source of motivation and clarity throughout this journey.

Lastly, I extend my appreciation to my family and friends for their constant encouragement and support, which have been my strength during this academic endeavour.



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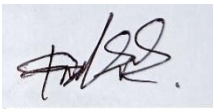
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Declaration

I, Steven Samuel Bose, hereby declare that the thesis report entitled “Assessing Trade Competitiveness through E-Business Porter’s Diamond Model Indicators in Bangladesh: An Econometric Method and MCDM Approach,” is my original work, prepared and submitted to the Department of Management, Daffodil International University, as part of the academic requirements for the BBA in Management program. This report has been completed under the guidance and supervision of Dr. Omar Faruk, Supervisor, Department of Management, and adheres to all institutional and copyright guidelines.

The content of this report is solely intended for academic purposes and complies with the standards set forth by the University for Thesis Submissions.



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Abstract

The rapid advancement of digital technology has transformed global trade and commerce, with e-business emerging as a key engine of economic growth and competitiveness. In this backdrop, Bangladesh's expanding e-business sector provides a unique opportunity to improve trade dynamics, but its competitive potential remains untapped. This thesis attempts to close this gap by utilizing an integrated framework that integrates Porter's Diamond Model with econometric and Multi-Criteria Decision-Making (MCDM) tools, notably VIKOR and TOPSIS. The study assesses important variables such as Internet Penetration Rate (IPR), Online Sales Volume (OSV), and Number of E-Business Firms (NEF) to uncover competitiveness drivers and provide actionable recommendations for stakeholders.

The methodology is based on rigorous statistical analysis, with Granger Causality and Unit Root Tests used to identify dynamic correlations and assure the stationarity of time-series data. The analytical processes were carried out using the computer languages R and Python, which allowed for precise and efficient data management, model creation, and visualization. The MCDM tools VIKOR and TOPSIS improve the decision-making process by ranking methods and selecting the best solutions. The findings demonstrate critical interdependence between the variables under study. The Internet Penetration Rate (IPR) was found as a crucial driver of online sales growth, whereas the Number of E-Business Firms (NEF) demonstrated the market's competitive structure. The study found that investing in digital infrastructure and encouraging innovation are critical to increasing trade competitiveness. In addition, the VIKOR and TOPSIS rankings gave actionable insights, emphasizing the importance of balanced strategies for e-business growth.

This thesis contributes to the academic literature by combining old and current analytical frameworks to evaluate e-business dynamics, providing a reproducible paradigm for future research in similar contexts. The ramifications go beyond academia to politicians and corporate leaders, offering a data-driven foundation for improving digital competitiveness. While the study is primarily concerned with Bangladesh, the findings have broader implications, providing insights for other developing countries seeking to use e-business for economic progress.

The study acknowledges its limitations, particularly its dependence on secondary data from free web sources, which may limit the extent and depth of the investigation. Future research might

include primary data collecting, broaden the geographical reach, and investigate future technologies such as artificial intelligence and blockchain to improve our understanding of e-business competitiveness. Finally, this thesis emphasizes the revolutionary potential of e-business as a catalyst for economic resilience and global trade integration, as well as the significance of strategic collaboration among government, industry, and academia in realizing its full potential.

Abbreviation

IPR	-	Internet Penetration Rate
OSV	-	Online Sales Volume
NEF	-	Number of E-Business Firms
MCDM	-	Multi-Criteria Decision-Making
VIKOR	-	Vlsekriterijumska Optimizacija I Kompromisno Resenje
TOPSIS	-	Technique for Order Preference by Similarity to Ideal Solution
GDP	-	Gross Domestic Product (if mentioned in your analysis)
ADF	-	Augmented Dickey-Fuller Test
KPI	-	Key Performance Indicator
ICT	-	Information and Communication Technology

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Chapter I: Introduction

1.1 Introduction

The e-commerce sector has expanded dramatically since the early 2000s, when Bangladesh lacked extensive internet access and a dependable online transaction system. In 2009, the Bangladesh Bank, the country's central bank, began allowing online transactions. In 2013, the Bangladesh Bank approved the use of international credit cards to buy and sell products and services online. Bangladesh placed 147th out of 176 countries in the ITU's 2017 ICT Development Index, an annual assessment that assesses the state of ICT development. The Bangladesh Telecommunication Regulatory Commission (BTRC) estimates that there will be 123.82 million internet subscribers by December 2021, with only 10.09 million using broadband connections and the rest using mobile internet(75, 2022).

As smartphone adoption and internet penetration rise, people are gradually migrating to online shopping rather than physical establishments. That's because online shopping is far more convenient than going down to your local market to get what you need. The BTRC estimates that by the end of December 2021, Bangladesh's total internet penetration will be 71.37%. This indicates that the vast majority of our country's population now has internet access. Companies understand this and are attempting to capitalize on the situation through e-commerce. So, let's look at the top ten e-commerce enterprises in Bangladesh (BD, 2022).

- Daraz
- Chaldal
- Shajgoj
- Rokomari
- Pickaoo
- Othoba
- Priyoshop
- Akerdeal
- Banglashoppers
- Sindabad

E-commerce has turned traditional business practices into lively, online processes. E-business, comprising digital marketing, online sales, and electronic data interchange has become essential

to global economy. As enterprises increasingly rely on digital platforms, policymakers, economists, and business executives need to understand how e-business is changing the dynamics of trade and competition.

Consumer preferences, ubiquity of the internet, and technological advancements have caused explosive growth in the e-business industry over the last decade. Online sales volumes have expanded, web traffic enhanced, and customer engagement heightened with the aid of digital media. Moreover, as a result of these changes, consumer behaviour changed but firm competitions have also changed. Firms that effectively implement e-business strategies often gain significant competitive advantages, leading to increases in profitability and market share.

E-business operations and trade dynamics, however, have a complicated and nuanced interaction. E-business can become more competitive by cutting costs associated with transactions, reaching a wider audience, and increasing customer satisfaction. However, it also comes with dangers, including those related to cybersecurity, regulatory compliance, and technological differences. Adopting strong analytical frameworks that can clarify the long-term linkages between different e-business variables and trade outcomes is essential to navigating these difficulties.

This thesis uses rigorous econometric approaches, like unit root tests and co-integration tests, to carefully analyse how e-business affects trade dynamics. This research looks at important e-business metrics such as online sales volume, website traffic, and customer involvement to find the underlying trends and patterns that affect trade competitiveness.

Alongside this research will also apply the VIKOR model along with TOPSIS Test for multiple decision-making in e-business with different criteria.

1.2 Analysis Process Justifications

A thorough method for evaluating stability, causality, and optimal decision-making in e-business performance analysis is provided by combining the Granger Causality, Unit Root, VIKOR, and TOPSIS tests. In order to provide accurate forecasting of e-business KPIs across time, the Unit Root Test is crucial for establishing the stationarity of time-series data. By determining the causative linkages between important variables, the Granger Causality Test illuminates interdependencies, such as those between internet traffic and sales conversion rates. While the TOPSIS technique ranks solutions according to their relative proximity to optimal company

performance, balancing several operational goals, the VIKOR Test emphasizes competing criteria in the e-business context, offering a compromise solution to aid in decision-making. When combined, these tests produce a strong analytical framework that is suited to the competitive and ever-changing world of e-business.

1.2.1 Introduction and Importance of the VIKOR Test

VIKOR: The VIKOR approach is well known for its simple easy going procedure, which enables decision-makers without advanced knowledge of convoluted mathematical models to use it. Its appeal in situations involving multi-criteria decision-making (MCDM) is influenced by its simplicity.

The approach is famous for finding almost accurate findings, which is important when making decisions involving multiple criteria. The trustworthiness of the generated compromise solution is increased by its design, which places it closest to the ideal solution and furthest from the negative perfect solution. (Chatterjee & Chakraborty, 2016a)

Decision-Making Situations: VIKOR has been used in several decision-making situations, especially where several factors must be assessed at once. This encompasses disciplines like:

Environmental Management: Assessing alternatives for sustainable practices.

Supply Chain Management: Assessing vendors according to various performance standards.

Healthcare: Choosing how to allocate resources or what treatments to offer.

Finance: Sorting potential investments according to risk and return standards.

1.2.2 Introduction and Importance of the Unit-Root Test

In time series analysis, unit-root tests are essential, especially for figuring out whether a series is stationary. Regarding their significance and correctness, the following are some important points:

Assessing Stationarity: Accurate modelling and forecasting depend on knowing if a time series is stationary or has a unit root, which can be found using unit-root tests. Inaccurate statistical conclusions may result from non-stationary data.

Accuracy Rate: Changes in the data's structural level may have an impact on the precision of unit-root testing. According to the report, these adjustments have the potential to skew the evidence in favor of a unit root, which could affect how reliable the test results are. By taking into consideration

numerous level shifts, the suggested techniques in the research seek to increase the accuracy of unit-root tests while also strengthening their robustness.

Applications of Unit-Root Analysis

Unit-root analysis can be frequently used in many different domains, such as:

Economics: To ascertain their long-term behavior and forecast future trends, it is widely used to examine economic time series data, including GDP, inflation rates, and stock prices.

Finance: Unit-root tests are used in the finance industry to evaluate the stationarity of asset prices and returns, which is essential for risk assessment and portfolio management.

Advantages of Unit-Root Test

Evaluation of Stationarity: In order to accurately model and forecast time series data, unit-root tests offer a way to evaluate stationarity in the data.

Trend Detection: The test helps direct future model selection by identifying whether a series is influenced by trends, guaranteeing more trustworthy financial or econometric analysis.

Limitations

Unit-root tests are crucial, but they have several drawbacks:

Structural Break Sensitivity: Structural level shifts can have a substantial impact on unit-root test performance. The tests may produce inaccurate results about the existence of a unit root if these adjustments are not taken into consideration.

Presumption of Shift Dates Known: Since the dates of structural shifts are frequently unknown in real-world data, many conventional unit-root tests make this assumption. If the shifts are uncertain, the results may be skewed.

1.2.3 Introduction to the TOPSIS Test

A popular technique in multi-criteria decision-making (MCDM), TOPSIS finds solutions that are the closest to the ideal and the furthest from the anti-ideal result. The method, which was first presented by Hwang and Yoon in 1981, gives decision-makers a simple way to handle complicated decision problems with conflicting criteria by ranking options according to how far they are from an ideal position. A popular technique in multi-criteria decision-making (MCDM) is called

TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), which finds answers that are the closest to the ideal and the furthest from the anti-ideal result. The method, which was first presented by Hwang and Yoon in 1981, gives decision-makers a simple way to handle complicated decision problems with conflicting criteria by ranking options according to how far they are from an ideal position.

Application of TOPSIS Test

Due to its effectiveness and ease of use, the approach is frequently used in a variety of decision-making situations, including:

Supply Chain Optimization: Evaluating the performance of suppliers based on a number of factors, including price, quality, and delivery time.

Project Prioritization: Projects are ranked in project management according to criteria such as risk, ROI, and cost.

Financial Analysis: Ranking possibilities according to risk, return, liquidity, and other financial parameters might help with investing decisions.

Healthcare: Assisting with decision-making in areas such as equipment selection, treatment prioritization, and healthcare provider assessment.

1.2.4 Introduction to the Granger Causality Test

A statistical hypothesis test called Granger Causality assesses if one time series may be used to forecast another. This method, which was first put forth by Clive Granger in 1969, examines the hypothesis that if the variable X “Granger-causes” variable Y , then information from previous values of X should still be able to predict Y even after taking into consideration the information from past values of Y . This approach, which is widely used in finance and economics, provides information about causal links that help with time-series analysis forecasting and model building.

Applications of Granger Causality Test

The applications of Granger Causality Test are many, some of them are mentioned below:

Macroeconomics Analysis: Granger causality is used in economic policy to investigate the relationship between one economic indicator, like inflation, and another, like GDP growth.

Financial Market Analysis: The test is frequently used to investigate the causal relationship between bond prices, stock indices, and exchange rates. This helps with risk assessment and portfolio management.

Environmental and Social Analysis: The Granger test has also been used to evaluate the causal relationships between economic outcomes and population expansion, environmental legislation, and technological advancements.

Marketing and Consumer Behavior: Granger causality can be used to examine whether changes in consumer demand are caused by marketing initiatives or by outside factors like social trends.

Process Summary

In particular, the research will:

Explain Important Variables: We would only consider variables related to Porter's Diamond Model regarding the fact that our analysis would be on the e-business system in Bangladesh. For detailed research, we have only considered 4 variables.

Perform Granger Causality Test: This test is very useful for determining the relationships between important business KPIs, which helps guide focused initiatives.

Perform Tests for Unit Roots: After collecting the data the Unit Root Test will be performed to justify whether the variables are stationary or not.

Utilize Co-Integration Tests: A statistical technique called a co-integration test is used to ascertain whether two or more time series variables are co-integrated, which indicates that even though they are non-stationary separately, they have a long-term equilibrium relationship.

Apply VIKOR Model: Multiple Decision-Making models would be applied in the e-business sector.

Apply TOPSIS Test: Multiple Decision-Making models would be applied as well.

Make Inferences: At last, we will make inferences.

This study adds to the expanding body of research on digital economics by methodically examining the relationship between e-business and commerce. It also provides useful insights for boosting enterprises' competitiveness in the digital era. The results should help firms optimize their

e-business strategies, direct lawmakers in the creation of rules that would be beneficial, and serve as a starting point for more research in this area.

1.3 Research Problem

Despite Bangladesh's significant growth in e-business, its worldwide competitiveness has yet to be explored. Existing research has been concentrated on traditional industries, with limited use of comprehensive frameworks such as Porter's Diamond Model in the digital arena. Furthermore, the absence of integration between time-series econometric methodologies and Multi-Criteria Decision-Making (MCDM) techniques in this context leaves a vacuum in comprehending the dynamic correlations between crucial e-business variables. This gap makes it difficult for policymakers and industry stakeholders to identify significant drivers of trade competitiveness and establish plans to improve the sector's performance in an increasingly competitive global market.

1.4 Objective of the Study

The fundamental goal of this research is to evaluate the trade competitiveness of Bangladesh's e-business sector using an integrated framework that incorporates Porter's Diamond Model, econometric tools, and Multi-Criteria Decision-Making (MCDM) approaches. Specifically, the study aims to investigate:

- I. Analyse major factors influencing e-business competitiveness in Bangladesh using Porter's Diamond Model variables such as Internet Penetration Rate (IPR), Online Sales Volume (OSV), and Number of E-Business Firms (NEF).
- II. Use time-series econometric approaches like Unit Root Tests, Granger Causality, and Co-Integration Tests to uncover the dynamic linkages and long-term equilibrium between e-business variables.
- III. Apply MCDM approaches, specifically VIKOR and TOPSIS, to assess the performance of e-business indicators and find the optimum year for trade competitiveness.
- IV. Provide policymakers and industry stakeholders with actionable knowledge to help the e-business sector in Bangladesh grow and sustain itself.
- V. Contribute to the existing literature by integrating Porter's Diamond Model with modern quantitative methods in the context of e-commerce, an area largely untouched in past study.

1.5 Scope of the Study

This research examines the trade competitiveness of Bangladesh's e-business sector using Porter's Diamond Model integrated with econometric methods and MCDM tools like VIKOR and TOPSIS. By focusing on variables such as Internet Penetration Rate (IPR), Online Sales Volume (OSV), and Number of E-Business Firms (NEF), the study offers a comprehensive analysis of the sector's growth dynamics and performance. This work aims to identify key drivers of competitiveness, evaluate long-term relationships between critical variables, and provide actionable insights for policymakers and industry stakeholders to enhance the e-business landscape.

1.6 Rationale of the Study

Bangladesh's e-business sector is growing rapidly, yet its potential for global competitiveness remains underexplored. Existing research predominantly focuses on traditional industries and lacks integration of quantitative decision-making methods with theoretical frameworks like Porter's Diamond Model. Addressing this gap, the study uses econometric tools and MCDM methods to analyse and rank performance indicators. This approach not only provides robust insights into e-business competitiveness but also establishes a framework for similar studies in other developing economies, contributing significantly to the literature.

1.7 Statement of the Problem

Despite the rapid growth of the e-business sector in Bangladesh, its competitive position in the global digital economy remains unclear. The absence of a comprehensive framework integrating theoretical and quantitative approaches leaves policymakers and stakeholders without actionable guidance to enhance sectoral performance. Existing studies neglect the dynamic relationships between key e-business variables and fail to leverage advanced decision-making methods, resulting in a limited understanding of the factors driving trade competitiveness. This study addresses these gaps by applying Porter's Diamond Model alongside econometric and MCDM analyses to evaluate the sector's competitive dynamics.

1.8 Limitations of the Study

This study faced several severe limitations, particularly due to its dependence on secondary data obtained solely from online sources. While using publically available free websites was less expensive, it limited the extent and depth of data collection. These sources frequently lacked

complete datasets and sophisticated analytical techniques that could provide more in-depth insights. As a result, essential research characteristics such as granularity and data validation were hampered.

Another drawback is the inherent bias and inconsistency in the quality of data obtained from open websites. Free sources are prone to discrepancies, missing data points, and probable errors. Furthermore, this study did not include access to premium, subscription-based databases, which limited the range and quality of data.

Despite including the website sources in the bibliography to promote transparency, these limits highlight the difficulties of conducting research with limited financial and technical resources. Future research could fill these gaps by including primary data collecting or utilizing paid, specialized databases to improve reliability and depth of analysis.

Chapter II: Literature Review

2.1 Introduction

This literature review aims to provide a comprehensive overview of the existing research on Porter's Diamond Model, its applications, and its relevance across various industries. The Diamond Model, formulated by Michael Porter, is a framework used to understand the competitive advantage of nations and industries by examining four interrelated determinants: factor conditions, demand conditions, related and supporting industries, and firm strategy, structure, and rivalry (*Porter's Five Forces Explained and How to Use the Model*, n.d.). This model has been extensively analyzed and applied in numerous fields, leading to a rich body of literature that sheds light on its theoretical foundations and practical implications.

In this literature review, we have categorized the relevant studies into seven distinct groups to systematically explore the breadth and depth of research conducted on Porter's Diamond Model. These categories are: Agriculture & Food, Analysis of Porter's Diamond Model, Application of Porter's Diamond Model, Banking, Digitalization, Export Industries, and Porter's Diamond Model Review. Each category provides a unique perspective on the model, highlighting its versatility and adaptability across different sectors and contexts.

The review initiates with the Agriculture & Food sector and delves into how the Porter Diamond Model has been used as an analytical framework for providing insights to competitiveness of agro products and food industries. Afterwards, the analytical foundation and criticism on Porter's Diamond Model are studied in the part of Analysis of Porter's Diamond Model. Providing thoughts about what it does well, what challenges limitation areas there and where could more be done (Alhosseiny, 2023; Constantin et al., 2022).

We then discuss how the Porter's diamond model used in different disciplines followed by various industries and regions to demonstrate its practical usability in terms of strategic management and public policy as shown next through the Application of Porter's Diamond Model. A bank is a financial entity that is authorized to accept checking and savings accounts as well as provide loans. Banks also offer associated services such individual retirement accounts (IRAs), certificates of deposit (CDs), currency exchange, personal loans, and safe deposit boxes (*How Banking Works, Types of Banks, and How To Choose the Best Bank for You*, n.d.). The banking literature is explored next and examined in light of how this model has been adapted to the financial services

industry to interpret the competitive dynamics within banking markets (Khoualed & Bouzerb, 2023; Naser, 2021).

The advent of technology has significantly impacted competitive landscapes, which is addressed in the Digitalization section. Here, the literature on how digital transformation interacts with the determinants of competitiveness in Porter's model is examined. Diane et al. Duygu Kizildag, Eonsoo Kim explored these criteria. Subsequently, the Export Industries section reviews studies that have applied the Diamond Model to understand and promote export competitiveness, particularly in manufacturing and high-tech industries (Isabelle et al., 2020; Kim et al., 1970; Kızıldağ & Uğurlu, 2023).

Finally, the Porter's Diamond Model Review section synthesizes overarching themes and insights from the broader body of literature, providing a meta-analysis of the model's impact and suggesting directions for future research.

This structured approach not only facilitates a clear and organized understanding of the existing research but also identifies gaps and opportunities for further investigation. By categorizing the literature into these seven key areas, this review aims to build a solid foundation for subsequent research endeavours and contribute to the ongoing discourse on competitive advantage and strategic management.

2.2 Sector-Wise Literature Review of Porter's Diamond Model

Porter's Diamond Model has been used in several sectors. Of all the literature reviews has been conducted those are segmented into categories which are listed below:

2.2.1 Agriculture & Food

The application of Porter's Diamond Model in the agriculture and food sector provides crucial insights into the factors driving competitiveness in this essential industry. This section reviews how the model has been used to analyse the dynamics of agricultural products and food industries, focusing on innovation, resource availability, market demand, and supporting industries.

Research highlights include the impact of technological advancements, supply chain efficiencies, and policy frameworks on competitiveness. Studies cover specific agricultural products like grains,

fruits, and livestock, as well as broader analyses of food production and distribution systems, including agribusiness and food processing.

By examining both local conditions and global trends, this section identifies key drivers of competitiveness, common challenges, and strategic recommendations. This review demonstrates the model's relevance to agriculture and food industries and suggests directions for future research.

In 2022 Hajar Alhosseiny from Misr University for Science & Technology showed applied Porter's diamond model. The research work focused on investigating the impact of Porter's business-level strategies on competitive advantage in the Food and Beverage (FB) sector. The findings was Porter's model suggests two main strategies: Low Cost-leadership and Differentiation, with the possibility of combining them into a Hybrid strategy. The study utilized a desk survey research approach, analysing data from the top 27 large FB companies in the U.S. and Canada over eight years. (Alhosseiny, 2022).

The study of Marius Constantin et al. utilized spatial econometric methods to analyse the relationship between the global vegetable market reactions and Romania's market demand it assessed the competitiveness of the Romanian vegetable chain using the Balassa index and Porter's diamond model at county and national levels. The research highlighted the increasing trade balance deficit for vegetables in Romania, particularly in the Bucharest-Ilfov region, and identified the best and worst-performing Romanian counties based on Porter's diamond model attributes (Marius Constantin, 2022).

A study conducted by Masnat Al-Hiary and Amer Jabarin in Jordan came out to be Jordan may have a comparative advantage in fruits and vegetables production due to its natural resources and climate, offering high returns. The sector faces challenges such as poor production technologies, lack of marketing infrastructure, and inadequate produce classification, impacting its competitiveness (Masnat Al-Hiary, 2010).

2.2.1.1 Limitations of the Agriculture and Food Sector

These three study is done in European and Middle Eastern region based on SWOT analysis.

2.2.2 Banking

The banking sector is necessary for economic stability and development, so the application of Porter's Diamond Model to this sector would give us a lot of information about its competitive

dynamics. The next part discusses how the model has been applied in banking competitiveness analysis, emphasizing regulatory design, technology innovation, market needs and financial architecture.

New research explores the factors of competitive advantage such as digital banking, financial regulations and the interplay between local and global practices in banking. Moreover, research is conducted on the resource use and strategies banks employ in providing financial services to domestic and international markets. Some studies also explored about challenges of the banking sector (*JAMI_5_1_34-39*, n.d.).

The study of Khoualed Aboubaker assesses the competitiveness of the Indian apparel retail industry using Porter's diamond model, identifying opportunities and challenges for foreign retailers in the market post-2006 trade liberalization. The industry has experienced rapid growth, supported by government initiatives like infrastructure development schemes and technology upgradation funds (Aboubaker Khoualed, 2023).

In the paper of Nahidah Naser in 2021 it is been illustrated that that specific digital banking services meeting consumer needs drive Fintechs to expand globally, filling gaps left by traditional financial institutions. It emphasizes that certain countries have a competitive advantage in digital financial inclusion, allowing FinTechs to thrive internationally (Naser, 2021).

2.2.2.1 Limitations of the Banking Sector

In the first paper only partial Porter's DM was used (opportunities and challenges). The second study overlooking other relevant theoretical frameworks or models that could provide additional insights into the phenomenon.

2.2.3 Digitalization

Digitalization is the process by which individuals, businesses, and organizations use digital tools to increase work speed, efficiency, and value. Digitalization is especially important for businesses since it can save time and open up new growth prospects (*Digitalization in Business*, n.d.).

The competitive landscape of industries has changed due to digitalization. This section examines how market demand, supporting industries, digital infrastructure, and technological improvements all affect competitive advantage as explained by Porter's Diamond Model.

Research looks at ways conventional sectors can remain competitive while simultaneously highlighting changes to digital business models, efficiency increases, and new market prospects.

This section highlights the main factors influencing digital competitiveness and its difficulties by combining numerous studies. It also shows how applicable the Diamond Model is to the digital age and offers potential directions for further investigation.

The paper of Diane A. Isabelle et al. investigates the relevance of Porter's Five Forces (P5F) framework by contrasting the mining industry, a resource-based, capital-intensive industry, with the information technology industry, a knowledge-intensive industry. This study aims to contribute to the debate on the framework's applicability in the 21st-century hypercompetitive business environment (Diane Isabelle, 2020).

Özlem Yaşar Uğurlu and Duygu Kızıldağ's paper underscores the transformative impact of digitalization on the competitive landscape of various industries by leveraging technologies like the internet, computers, tablets, smartphones, the internet of things, cloud computing, big data, and analytics.(Duygu Kızıldağ, June 2023).

The study of Eonsoo Kim focused on Korean cyber malls, representing B2C commerce, and may not directly apply to other e-business variants like B2B, B2G, G2C, and C2C (Eonsoo Kim).

The analysis conducted by James Rajasekar in 2013 using Michael Porter's Five Forces Model identified the most impactful competitive forces in the Oman telecommunications industry. These include (James Rajasekar, 2013):

- Rivalry among competitors and the threat of substitutes were identified as the strongest competitive forces.
- Additionally, the threat of entry and power of buyers were found to have significant impacts, while the power of suppliers had limited influence on the industry.

In the paper of Nahidah Naser in 2021 it is been illustrated that that specific digital banking services meeting consumer needs drive Fintechs to expand globally, filling gaps left by traditional financial institutions. It emphasizes that certain countries have a competitive advantage in digital financial inclusion, allowing Fintechs to thrive internationally (Naser, 2021).

The study of Wawan Dhewanto et al. emphasises that the competitiveness of ICT industry clusters in West Java is supported by good input factors and demand conditions, encouraging innovation.

However, the presence of supporting and related industries is lacking, particularly in local suppliers and complementary products, which are still heavily reliant on foreign supplies (Wawan Dhewanto, 2015).

2.2.3.1 Limitations of the Digital Sector

The studies above focuses on the technological sector depending on porter's five forces but are limited to b2c or b2b model.

2.2.4 Export Industries

Exports are goods and services manufactured in one country and sold to customers in another. International trade consists of both exports and imports. Instead of limiting themselves to their geographical borders, countries frequently seek external markets around the world for trade, resulting in more revenue and transactional opportunities (*What Are Exports?*, n.d.).

The export sector is essential to both global trade and economic expansion. This section explores the application of Porter's Diamond Model to the analysis of export industry competitiveness, with particular emphasis on related and supporting industries, firm strategy, factor conditions, and demand conditions (Dr. Sushil Kumar, 2023).

Empirical studies demonstrate the ways in which innovation, resource quality, market accessibility, and global trade regulations impact export competitiveness. Research also looks at tactics used by businesses to improve their export performance and adjust to changes in international markets.

This section examines the many uses of the Diamond Model to identify the main factors that influence export competitiveness as well as its obstacles. It gives strategic insights for improving the performance of international trade and illustrates how the model may be applied to export sectors.

The research paper of Dr. Sushil Kumar in 2023 conducted on variables related to the determinants of export competitiveness in scientific instruments export industries in Ambala cluster. The study identified six variables out of sixteen with Eigenvalues greater than 1.0, indicating their significance in determining export competitiveness (Kumar, 2023).

The paper of Minjing Peng establishes a regression model using the Diamond Model, finding that research expenditure and development significantly boost Guangdong's export trade volume in 2021. Through empirical analysis from 2010 to 2019, it concludes that the tertiary industry's impact on export trade is substantial, suggesting a focus on cultivating the science and technology service industry for enhanced service export trade (Minjing Peng, 2021).

Seyed Fathollah Amiri Aghdaie illustrated in their study that various barriers to Iran's saffron export using Michael Porter's Diamond Model, including, Demand conditions, related and supporting industries, firm strategy, structure, and rivalry, government, and chance Factor conditions were found not to be important barriers to Iran's saffron export Related and supporting industries, firm strategy, structure, and rivalry, demand conditions, chance, and government were all identified as important barriers to Iran's saffron export (Seyed Fathollah Amiri Aghdaie).

2.2.4.1 Limitations of the Export Sector

The study conducted on a specific region like Ambala or on a specific product like saffron.

2.2.5 Porter's Diamond Model Review

Based on a critical analysis of five seminal works, this section presents an overview of Porter's Diamond Model. These foundational studies provide thorough understandings of the theoretical underpinnings of the paradigm and its implementation in many settings.

In order to comprehend the fundamental elements of the Diamond Model—factor conditions, demand circumstances, associated and auxiliary industries, and firm strategy—the papers were reviewed. In addition to filling in gaps and assisting in the formulation of research topics, this review helped to set up an organised framework for the research paper.

By combining these important studies, this section provides a strong foundation for creating the research framework by highlighting the model's advantages, disadvantages, and possible research opportunities.

The research paper of Dr. Sushil Kumar in 2023 conducted on variables related to the determinants of export competitiveness in scientific instruments export industries in Ambala cluster. The study identified six variables out of sixteen with Eigenvalues greater than 1.0, indicating their significance in determining export competitiveness (Kumar, 2023).

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In the paper of Nahidah Naser in 2021 it is been illustrated that that specific digital banking services meeting consumer needs drive Fintechs to expand globally, filling gaps left by traditional financial institutions. It emphasizes that certain countries have a competitive advantage in digital financial inclusion, allowing Fintechs to thrive internationally (Naser, 2021).

The study of Pei-Hsuan Tsai et al. utilized Porter's diamond model to assess the competitiveness of Taiwan's solar photovoltaic industry, focusing on six dimensions: firm strategy, government, structure, and rivalry, demand conditions, chance, factor conditions, and related/supporting industries in 2021. The proposed industry evaluation model incorporated the DEMATEL technique to establish influential relationships between indicators, the DEMATEL-based analytic network process to determine influential weights, and the VIKOR method to evaluate industry development performance gaps (Pei-Hsuan Tsai1, 2021).

Yan Xu's analysis helps in understanding the shortcomings of sports characteristic towns and proposes countermeasures to enhance their competitiveness in his paper in 2021. MATLAB simulation results demonstrate that the 'Diamond Model' theory can boost the overall competitiveness of these towns, reduce resource consumption, and predict future development trends effectively (Xu, 2021).

2.2.6 Application of Porter's Diamond Model

This section examines the several ways that Porter's Diamond Model is applied in different sectors and geographical areas. Through the examination of factor conditions, demand conditions, linked and supporting industries, and firm strategy, the model has been widely utilised to analyse competitive advantage.

Studies demonstrate how the model is used to determine competitive advantages and disadvantages in industries like manufacturing, services, and technology. Research findings also indicate that it is useful in developing company strategies and strategic policies (Cegliński, 2017).

This section highlights the Diamond Model's adaptability and practical significance by examining a number of applications. It also offers insights into how diverse sectors use the model to boost their competitiveness.

The study of Khoualed Aboubaker assesses the competitiveness of the Indian apparel retail industry using Porter's diamond model, identifying opportunities and challenges for foreign retailers in the market post-2006 trade liberalization. The industry has experienced rapid growth, supported by government initiatives like infrastructure development schemes and technology upgradation funds (Aboubaker Khoualed, 2023).

In 2022 Hajar Alhosseiny from Misr University for Science & Technology showed applied Porter's diamond model. The research work focused on investigating the impact of Porter's business-level strategies on competitive advantage in the Food and Beverage (FB) sector. The findings was Porter's model suggests two main strategies: Low Cost-leadership and Differentiation, with the possibility of combining them into a Hybrid strategy. The study utilized a desk survey research approach, analysing data from the top 27 large FB companies in the U.S. and Canada over eight years. (Alhosseiny, 2022).

Asefeh Asemi et al. calculated data from 21 managers and experts in the cheminformatics industry and were analyzed using multicriteria decision-making methods, specifically MCDM techniques. The research utilized methods that were suitable for the research type, purpose, and variables involved in the study, ensuring compatibility and reliability in the analysis of the competitive situation in the cheminformatics industry (Asefeh Asemi, 2022).

Jerry Chik depicted that larger manufacturers like SPX are diversifying into international markets due to growing demand, while smaller manufacturers face challenges in commanding buyer respect and loyalty, also the government policies and technological advances are shifting power towards industry competitors and new entrants with patented and differentiated products, potentially disrupting the industry structure (Chik, 2021).

Tae Won Chung's paper is the study of the identification of key elements that contribute to the competitiveness of logistics clusters. These key elements include efficient transportation networks, advanced technology adoption, and supportive government policies (CHUNG, 2016).

Sanmath S. Shetty wrote that the food delivery apps industry is considered a lucrative business opportunity within the hospitality industry, with significant growth potential in the Indian market (Dr. Sanmath S. Shetty, 2023).

Özlem Yaşar Uğurlu and Duygu Kizildag's paper underscores the transformative impact of digitalization on the competitive landscape of various industries by leveraging technologies like the internet, computers, tablets, smartphones, the internet of things, cloud computing, big data, and analytics.(Duygu Kızıldağ, june 2023).

The study of Eonsoo Kim focused on Korean cyber malls, representing B2C commerce, and may not directly apply to other e-business variants like B2B, B2G, G2C, and C2C (Eonsoo Kim).

Ana-Maria GRIGORE states that exiting barriers in the Romanian book publishing market are relatively low, as publishing houses do not have significant fixed costs. However, customers hold power over pricing and publisher profits. Internal and external forces, influence the market with a few suppliers dominating the market, posing a threat to publishers. There is a shift in book consumption paradigms among new generations in Romania (GRIGORE, 2024).

The analysis conducted by James Rajasekar in 2013 using Michael Porter's Five Forces Model identified the most impactful competitive forces in the Oman telecommunications industry. These include(James Rajasekar, 2013):

- Rivalry among competitors and the threat of substitutes were identified as the strongest competitive forces.
- Additionally, the threat of entry and power of buyers were found to have significant impacts, while the power of suppliers had limited influence on the industry.

The study of Manoj Joshi focuses on enhancing the competitiveness of the Indian automobile industry using Porter's Diamond model. It identifies critical roadblocks hindering the industry's global expansion and suggests measures to overcome these obstacles. The study emphasizes the importance of factors like labor productivity, cost efficiency, proximity to markets, economic policies, and infrastructure in improving competitiveness (Joshi, 2023).

The research paper of Dr. Sushil Kumar in 2023 conducted on variables related to the determinants of export competitiveness in scientific instruments export industries in Ambala cluster. The study

identified six variables out of sixteen with Eigenvalues greater than 1.0, indicating their significance in determining export competitiveness (Kumar, 2023).

The study of Mansour Saleman M. Lotayif identified significant relationships between scanning activities and the adopted strategies, refuting the dichotomization stream of literature. Firms can adopt both differentiation and cost leadership strategies simultaneously, contrary to the belief that they lead to being stuck in the middle (Lotayif, 2010).

In the paper of Nahidah Naser in 2021 it is been illustrated that that specific digital banking services meeting consumer needs drive Fintechs to expand globally, filling gaps left by traditional financial institutions. It emphasizes that certain countries have a competitive advantage in digital financial inclusion, allowing Fintechs to thrive internationally (Naser, 2021).

The study of Eoin O'Malley et al. did not find well-developed clusters as described by Porter in Ireland, supporting previous critiques of Porter's model. The research examined three successful Irish sectors and found that elements of Porter's model are relevant, but there are significant differences from Porter's clusters in practice (PAULA CLANCY, 2010).

The study of Pei-Hsuan Tsai et al. utilized Porter's diamond model to assess the competitiveness of Taiwan's solar photovoltaic industry, focusing on six dimensions: firm strategy, government, structure, and rivalry, demand conditions, chance, factor conditions, and related/supporting industries in 2021. The proposed industry evaluation model incorporated the DEMATEL technique to establish influential relationships between indicators, the DEMATEL-based analytic network process to determine influential weights, and the VIKOR method to evaluate industry development performance gaps (Pei-Hsuan Tsai1, 2021).

The research of Richard S. Allen identified a core list of strategic practices that better define each of Porter's generic strategies, highlighting specific practices associated with each strategy's success (Richard S. Allen, 2006).

Seyed Fathollah Amiri Aghdaie illustrated in their study that various barriers to Iran's saffron export using Michael Porter's Diamond Model, including, Demand conditions, related and supporting industries, firm strategy, structure, and rivalry, government, and chance Factor conditions were found not to be important barriers to Iran's saffron export Related and supporting

industries, firm strategy, structure, and rivalry, demand conditions, chance, and government were all identified as important barriers to Iran's saffron export (Seyed Fathollah Amiri Aghdaie).

2.2.7 Review of Porter's Diamond Model

This section explores Porter's Diamond Model's theoretical analysis, looking at the fundamental elements and how they relate to one another. The efficacy of the model in explaining competitive advantage at the national and industrial levels is evaluated critically by the analysed studies.

This category of research identifies the model's shortcomings and potential improvement areas while also highlighting the model's advantages in offering a formal framework for competitiveness analysis. Academics have disagreed over how well the model fits into various contexts and adapts to sudden changes in the world.

Through the synthesis of various evaluations, this section provides a fair assessment of the theoretical contributions of the Diamond Model as well as its areas in need of improvement, opening the door to more complex and flexible applications.

The study of Khoualed Aboubaker assesses the competitiveness of the Indian apparel retail industry using Porter's diamond model, identifying opportunities and challenges for foreign retailers in the market post-2006 trade liberalization. The industry has experienced rapid growth, supported by government initiatives like infrastructure development schemes and technology upgradation funds (Aboubaker Khoualed, 2023).

Alexander Friedrich Eickelpasch et al. conducted a study that measured Relationship between Locational Factors and Innovativeness, Impact of Competitive Environment on Firm Performance and Economic Policy Implications (Alexander Friedrich Eickelpasch, 2007).

- There is a positive link between locational factors, particularly hard factors, and firms' innovativeness.
- Cooperation intensity in different areas plays a crucial role in enhancing innovative performance.
- Emphasizes the importance of stimulating networking and cooperation intensity for innovation activities.
- Improving locational conditions, especially hard factors, benefits innovative firms and can be utilized as a tool for regional policy.

- Contrary to Porter's Diamond model predictions, a stronger competitive environment, indicated by a high number of competitors or the presence of important competitors, leads to worse firm performance.

The study of Ari Pranoto conducted an analysis of external factors at PT Gipan Metal Teknik Indonesia using Porter's Five Forces method to determine the competitive advantage strategy (Ari Pranoto, 2024).

The paper of Diane A. Isabelle et al. investigates the relevance of Porter's Five Forces (P5F) framework by contrasting the mining industry, a resource-based, capital-intensive industry, with the information technology industry, a knowledge-intensive industry. This study aims to contribute to the debate on the framework's applicability in the 21st-century hypercompetitive business environment (Diane Isabelle, 2020).

Snehal Pawar, Dr. Yogesh Hole et al. showed how the paper explores Michael E. Porter's Five Forces model, emphasizing the importance of core competencies, cost-effective practices, and innovative strategies to achieve competitive advantage. It highlights the model's significance in measuring competitive advantage and building business competitiveness at a national level. (Dr. Yogesh Hole, 2019).

The study of Göksel KORKMAZ focuses on the competitiveness of the Turkish defense industry and emphasizes the need for sectoral competitiveness studies. It highlights the use of Porter's Diamond Model to assess national advantage and stresses the importance of ecosystem understanding for competitiveness. The study also discusses challenges such as currency depreciation affecting costs and the dependency on foreign suppliers in the defense sector (Göksel KORKMAZ, 2021).

The research paper of Dr. Sushil Kumar in 2023 was conducted on variables related to the determinants of export competitiveness in scientific instruments export industries in the Ambala cluster. The study identified six variables out of sixteen with Eigenvalues greater than 1.0, indicating their significance in determining export competitiveness (Kumar, 2023).

The study utilized spatial econometric methods to analyse the relationship between the global vegetable market reactions and Romania's market demand it assessed the competitiveness of the Romanian vegetable chain using the Balassa index and Porter's diamond model at county and

national levels. The research highlighted the increasing trade balance deficit for vegetables in Romania, particularly in the Bucharest-Ilfov region, and identified the best and worst-performing Romanian counties based on Porter's diamond model attributes (Marius Constantin, 2022).

Maja Mutavdžija and Ivana Martinčević revealed the importance of conducting a value chain analysis to determine activities impacting business outcomes and selecting appropriate strategies based on Porter's value chain framework in 2019. The paper discusses the practical application of Porter's value chain in organizations, emphasizing the significance of value chain analysis for identifying activities that add value or generate costs. The methodology involves conducting a value chain analysis to gain insights into individual organizational activities (Martinčević, 2019).

The paper of Minjing Peng establishes a regression model using the Diamond Model, finding that research expenditure and development significantly boost Guangdong's export trade volume in 2021. Empirical analysis from 2010 to 2019, it concludes that the tertiary industry's impact on export trade is substantial, suggesting a focus on cultivating the science and technology service industry for enhanced service export trade (Minjing Peng, 2021).

The paper of Osiebuni Obu explored Various studies that support the significance of industry characteristics and supplier power in influencing seller profitability, highlighting the importance of understanding industry dynamics for assessing industry attractiveness (OBU, 2022).

Charis Vlado's research found that the majority of criticisms of Porter's diamond model focus on its home-based nature, lacking in defining multinational enterprises' activities and the globalized nature of industries in the modern business world (Vlados, 2019).

The study research paper of Wang Li et al. utilized Porter's diamond model to analyze the influencing factors of cultural industry competitiveness in Anhui province, with factors like factor conditions, demand conditions, related and supporting industries, firm strategy, structure and rivalry, and chance as independent variables (Wang Li, 2023).

Yan Xu's analysis helps understand the shortcomings of sports characteristic towns and proposes countermeasures to enhance their competitiveness in his paper in 2021. MATLAB simulation results demonstrate that the 'Diamond Model' theory can boost the overall competitiveness of these towns, reduce resource consumption, and predict future development trends effectively (Xu, 2021).

2.3 Summary of Literature Review

This table below, comprises all the most relevant studies which were linked with this particular thesis. This table divided six different columns denoting a particular sector of each studies. From this table we can easily classify every area of the most relevant literature.

Table: 2.1: Summary of Literature

Sl	Study Ref	Focus Area	Key Contribution	Practical Implementation	Methodology	Gaps Identified
1	Regression Analysis of the Impact of Guangdong Province's Tertiary Industry on Export Trade Based on the Diamond Model(Peng & Liang, 2021)	Impact of Guangdong's tertiary industry on export trade	Assesses how tertiary industry factors like R&D expenditure and development level influence Guangdong's export trade using Porter's Diamond Model	Identifies policy recommendations to increase export commerce through tertiary industry growth and R&D investment	Unit root, co-integration, and stepwise regression tests on tertiary industry data from 2010–2019	Lacks focus on short-term impacts and does not include government action and opportunity due to data constraints.
2	Using Porter's Diamond Model to Assess the Competitiveness of Taiwan's Solar Photovoltaic Industry(Tsai et al., 2021)	Taiwan's Solar Photovoltaic industry competitiveness	Provides a six-dimensional framework to enhance competitiveness and assesses factor interactions using DEMATEL-based analytic network process (ANP) and modified VIKOR for gap analysis	Enables industry participants in putting competitive strategies for technology-driven performance enhancement into practice	DEMATEL, ANP, and modified VIKOR	Limited indicator choice and suggests alternative MADM models for broader assessment
3	A comparative analysis of VIKOR method and its variants(Chatterjee & Chakraborty, 2016b)	Comparative analysis of VIKOR and its variants for MCDM problems	Explores original VIKOR and five variants for decision-making in conflicting criteria	Allows for selecting the best VIKOR variation to settle disputes in situations involving criteria-based decision-making	Demonstrative examples using ranking performance and Spearman's coefficient.	Interval VIKOR performs poorly under imprecise data; suggests fuzzy VIKOR for better results in uncertain scenarios

4	A comparative case study of the VIKOR and TOPSIS rankings similarity(Shekhovtsov & Sałabun, 2020)	Comparison of VIKOR and TOPSIS rankings in MCDM	Explores ranking similarity using simulated decision matrices and multiple correlation coefficients	Enables decision-makers comprehend ranking techniques to improve the dependability of multi-criteria assessments	Simulations with varying criteria, Spearman's, and rank similarity coefficients	Limited application to real-world decision-making problems; requires extension to diverse practical datasets
5	Portfolio Management: Stock Ranking by Multiple Attribute Decision-Making Methods(Dedania et al., 2015a)	Stock ranking for balanced portfolio selection in the Indian IT sector using MADM methods	Provides a ranking system using SAW, AHP, TOPSIS, and VIKOR with p-norm adaptations, offering a more flexible, data-driven approach to stock selection	Gives financial experts the resources they need to build IT-related stock portfolios that are efficient and balanced	Comparative analysis on 13 IT stocks using 13 criteria, with rankings performed via a custom MATLAB GUI	Further validation needed across sectors and asset classes; potential for testing additional MADM methods (e.g., ELECTRE, PROMETHEE)
6	Methodical Aspects of MCDM Based E-Commerce Recommender System(Bączkiewicz et al., 2021)	Multi-Criteria Decision-Making (MCDM) in e-commerce recommender systems.	Proposes a hybrid approach using TOPSIS-COMET, COCOSO, EDAS, MAIRCA, and MABAC to construct compromise rankings	Leverages advanced recommendation systems to increase consumer happiness in e-commerce platforms	Illustrative case study on mobile phone selection, CRITIC weighting method, and sensitivity analysis	Limited real-world application beyond e-commerce; potential computational complexity for large datasets
7	Compromise Solution by MCDM Methods: A Comparative Analysis of VIKOR and TOPSIS(Opricovic & Tzeng, 2004)	Mobile Phone Selection Problem	Proposed a DSS for mobile phone selection	Utilises hybrid decision-support systems to improve consumer choice tactics in the retail and technology sectors.	Utilized hybrid MCDM methods like TOPSIS-COMET	Few criteria and models used in prior studies
8	Multiattribute Decision Making Based on Novel Score Function of Intuitionistic Fuzzy Values and Modified VIKOR Method(Zeng et al., 2019)	General MCDM Application in Decision-Making	Highlighted benefits of hybrid MCDM approaches	Improves decision-making in fields that need accurate evaluations in	Applied fuzzy logic and Copeland ranking strategy	High complexity in traditional methods

				the face of uncertainty		
9	VIKOR method for multiple criteria group decision-making under 2-tuple linguistic neutrosophic environment(Wei et al., 2020)	Decision-making under uncertain environments using 2-tuple linguistic neutrosophic numbers.	Combines VIKOR with 2TLNNs to resolve conflicts in criteria and applies it to green supplier selection.	Enhances supplier selection and supply chain performance in unpredictable circumstances	Extends VIKOR with 2TLNNs and IV2TLNNs , using aggregation operators and compromise solutions.	Limited validation across real-world datasets and decision-making fields.
10	Granger Causality: A Review and Recent Advances(Shojaie & Fox, 2021)	Evolution and Applications of Granger Causality	Reviews advancements from linear models to non-linear, high-dimensional frameworks.	Helps economists and policymakers in determining causal links for better strategic planning	Linear VAR, network causality, Bayesian models, and machine learning-based methods for time-series	Challenges in handling non-linearity, confounders, and computational complexity with high-dimensional data
11	Selection of Maintenance Strategy for Aircraft Systems Criteria Decision Making Methodologies (Ahmadi et al., n.d.)	Maintenance Strategy Selection for Aircraft Systems	Proposed a methodology combining AHP, TOPSIS, VIKOR, and benefit-cost ratio for ranking maintenance strategies	Supports in prioritizing repair plans to guarantee aircraft systems operate efficiently	Multi-Criteria Decision-Making (MCDM) techniques applied through case studies in aviation systems	Difficulty in handling conflicting criteria; need for improved modeling of intangible benefits
12	Enhancing Competitiveness of The Indian Automobile Industry: A study Using Porter's Diamond Model(Joshi & Dixit, 2011)	Competitiveness of the Indian automobile industry using Porter's Diamond	Provides insights into labor productivity, infrastructure, and policy impacts	Offers information on enhancing infrastructure and productivity in the Indian auto industry	Qualitative analysis with regional data	Lack of emphasis on global branding and domestic innovation
13	Porter's Diamond Approaches and the Competitiveness Web(Vlados, 2019)	Evolution of Porter's Diamond model in national competitiveness	Proposes the "competitiveness web" to expand Porter's Diamond, integrating broader	Improves our knowledge of competitiveness by examining socioeconomic factors at the national	Literature review and critical analysis of Porter's Diamond Model	Lack of empirical testing for the competitiveness web; requires further exploration to

			socioeconomic factors and extending analysis from the national to the global level	and international levels		validate expanded socioeconomic dimensions
14	Digitalization and Business: A View From Porter's Five Forces(Kızıldağ & Uğurlu, 2023)	Impact of digitalization on business strategies through Porter's Five Forces model	Discusses the role of digitalization in enhancing competitiveness and sustainability of businesses; evaluates its effects on the competitive landscape	Enables businesses to get a competitive edge by integrating digital transformation with traditional methods	Conceptual analysis; literature review on digitalization, competitive strategies, and Porter's Five Forces	Need for frameworks that integrate digitalization into traditional business strategy models; exploration of the human element in digital transformation
15	Factors Influencing Cultural Industry Competitiveness in Anhui Province Using Porter's Diamond Model and the Mediating Effect of Government Support (Li et al., 2023)	Evaluating the relationships between factor conditions, demand conditions, related and supporting industries, firm strategy, and government support with cultural industries	Identified significant and insignificant relationships among various factors affecting the development of cultural industries, highlighting the role of government support in mediating relationships	Provides policymakers with information on how to improve competitiveness through resource management and targeted government assistance	Quantitative analysis using regression techniques, correlation coefficients, and hypothesis testing	Lack of significant influence from factor conditions on cultural industries; need for improved human capital and resource management in Anhui
16	Porter Diamond Model and Internationalization of Fintechs (Naser, 2021)	Examination of how digital financial inclusion drives the internationalization of Fintechs using Porter's Diamond Model	Demonstrates the role of digital financial inclusion in the internationalization of Fintechs, highlighting the competitive advantages and challenges they face	Helps fintech startups expand their worldwide markets by utilizing digital financial inclusion	Literature review and theoretical analysis based on Porter's Diamond Model	Need for empirical studies on Fintech impact, regulatory frameworks, consumer protection, and financial stability
17	Hard and soft locational factors, innovativeness	Impact of locational	Provides empirical	Helps regional	Structural equation	Limited analysis on

	and firm performance: an empirical test of Porter's Diamond model at the micro-level(Stephan, n.d.)	factors on innovativeness and firm performance, with a focus on Porter's Diamond Model predictions	evidence of locational factors' influence on firm innovativeness and performance, noting strong local competition and a locally focused market impede performance	industries take advantage of locational characteristics to boost company performance and innovation	modelling using PLS path modelling approach; sample of 2,100 East German firms	customer sophistication as a factor in local demand conditions; lacks exploration of micro-level competition's impact outside high-tech sectors and knowledge-intensive services
18	Industry Analysis of Food Delivery Applications using Porter's Five Forces Model(<i>Industry Analysis of Food Delivery Applications Using Porter's Five Forces Model</i> , n.d.)	Food Delivery Applications within the Hospitality Industry in India	Offers an industry analysis on the food delivery apps sector in India, highlighting its market potential, barriers, and growth projections	Supports food delivery companies to improve their marketing tactics and deal with the constraints of competition	Secondary data collection from research papers, industry reports, company documents, and field experts; application of Porter's Five Forces Model	Limited focus on strategic responses for coping with high bargaining power of buyers and rivalry; need for additional insights on market-specific challenges
19	Testing the Applicability of Porter's Generic Strategies in the Digital Age: A Study of Korean Cyber Malls(Kim et al., 1970)	Analysis of e-business strategies in Korean cyber malls, focusing on B2C commerce	Highlights the importance of hybrid strategies over cost leadership in e-business, identifies firm type's moderating effect on strategy performance	Enhances the development of e-business platform tactics in competitive online markets.	Surveys conducted through an online questionnaire distributed to 1,009 online shopping malls, with a final sample of 75 firms	Limited to B2C cyber malls, narrow country focus may not apply to other regions, and low response rate raises representativeness concerns
20	E-commerce Development in Bangladesh(Karim & Qi, 2018)	E-commerce Growth	Highlights the rapid growth of e-commerce in Bangladesh and its competitiveness in Asia.	Encourages government and policymakers to address shortcomings in the e-commerce sector	Secondary data analysis and a questionnaire-based survey to understand	Lack of consumer and merchant knowledge about the e-commerce system, and absence of clear

					consumer perceptions	government policy leading to confusion among traders and consumers
21	Economic Analysis on the Competitiveness of Small Towns with Sports Characteristics under the Guidance of the "Diamond Model" Theory(Xu, 2021)	Analysis of the competitiveness of sports characteristic towns in China using the "Diamond Model"	Proposes a competitive analysis method using k-clustering to enhance accuracy in prediction and competitiveness	Offers resources for enhancing sustainability and competitiveness in niche regional economies	Utilizes Genetic Algorithm (GA) for iterative analysis, K-mean clustering, and MATLAB simulation	Limited data availability; challenges in clustering and external interference effects on predictions

2.4 Literature Gap

Here all the gaps those were identified from those studies. These are the summarized versions of the gaps from each groups and compiled into following categories.

Summarized Improvements for Each Category:

2.4.1 Lack of Empirical Validation:

- Improvement: Incorporate empirical data or case studies to validate theoretical models and ensure practical applicability.

2.4.2 Limited Geographical Scope:

- Improvement: Expand the geographical scope to include multiple regions or countries for a more comprehensive perspective.

2.4.3 Insufficient Practical Recommendations:

- Improvement: Include specific policy suggestions and practical recommendations for industry stakeholders and policymakers based on the findings.

2.4.4 Absence of Comparative Analysis:

- Improvement: Conduct comparative analyses with other industries or regions to identify common challenges and draw more general conclusions.

2.4.5 Overemphasis on Theoretical Models:

Improvement: Balance theoretical insights with practical challenges and specific details to enhance the research's relevance and applicability.

2.4.6 Lack of Detailed Data or Case Studies:

- Improvement: Incorporate detailed case studies, primary data collection, and specific examples to provide a richer and more practical understanding of the topics.

2.4.7 Limited Discussion on Challenges and Solutions:

- Improvement: Provide detailed discussions on the challenges identified and suggest specific, actionable solutions to address them.

2.5 Gap Worked On

It defines clearly the purpose of the research after the review of related literature. A critical review of available studies on Porter's Diamond Model reveals that no prior study has used the model with e-business by integrating MCDM methods, specifically VIKOR and TOPSIS, along with unit-root testing. This gap is very significant since the application of MCDM integrated with unit-root tests within the e-business framework through Porter's Diamond Model remains unexplored. The method is used is MCDM (Multi-criteria Decision Making) VIKOR based on the analysis Pei-Hsuan Tsai et al. (Tsai et al., 2021) also Bartłomiej Kizielewicz's study on Methodical Aspects of MCDM Based E-Commerce Recommender System (Bączkiewicz et al., 2021). The TOPSIS method is also applied for further robustness of the analysis. From the study of Andrii Shekhovtsov's A comparative case study of the VIKOR and TOPSIS rankings similarity (Shekhovtsov & Sařabun, 2020) the model is executed.

To address this gap, the present study will concentrate on applying Porter's Diamond Model to the e-business sector using time series data and unit-root tests for precision. The research will further incorporate VIKOR and TOPSIS methods for decision-making analysis to add a new dimension to the existing literature.

This contribution adds to the existing body of research by integrating Porter's Diamond Model with advanced statistical tools and decision-making approaches, filling up an important gap in the literature on the competitiveness of e-business sectors.

The paper used the model of Minjing Peng and Min Liang's model to calculate the time series e-business data regarding the Diamond Model (Minjing Peng, 2021). Moreover, we will use the VIKOR and TOPSIS after the literature review, and the object of this thesis is clarified. We have sorted all possible literature on Porter's diamond model along with their gaps for multiple decision-making. Since we will be dealing with time-series data, for more sturdiness we have also applied Granger Causality method from Granger Causality: A Review and Recent Advances (Shojaie & Fox, 2021).

Porter's Diamond Model has mostly been applied to traditional business sectors, with little focus on e-business or e-commerce. This work addresses this gap by applying the model to the digital environment and incorporating modern approaches such as time series analysis and Multi-Criteria Decision-Making (MCDM). A distinctive component of this study is the use of MCDM techniques—VIKOR and TOPSIS—on time series data to analyse and rank performance across multiple years, determining the best-performing year inside the e-business framework. By merging these factors into a single framework, the study provides a novel perspective, greatly increasing the existing literature on e-business competitiveness. These are the all executed methods and models in this thesis.

2.6 Conclusion

This literature review analysis found a major gap in the application of Porter's Diamond Model to the e-business industry, namely in the integration of unit-root testing with Multi-Criteria Decision-Making (MCDM) techniques like as VIKOR and TOPSIS. These methods have never been combined in a study before. To close this gap, this study will use unit-root tests and time series data to apply Porter's Diamond Model to e-business, combining VIKOR and TOPSIS for decision-making analysis. By combining cutting-edge statistical tools with decision-making techniques, this study seeks to increase the literature's understanding of e-business competitiveness.

Chapter III: Methodology

3.1 Introduction

This study's methodology uses econometric and multi-criteria decision-making (MCDM) techniques to investigate how Porter's Diamond Model might be applied to Bangladesh's e-business industry. Regression analysis, unit root tests and MCDM techniques—specifically, VIKOR and TOPSIS—are used in this study to examine important indicators influencing trade competitiveness. A strong framework that offers both accurate statistical insights and ideal decision-making models is provided by the combination of econometric and MCDM methodologies. In order to help discover important aspects in the e-business sector, the technique uses this framework to rank variables by competitive priority, guarantee data stability, and clarify causal links.

3.2 Theoretical Perspectives

Porter's Theory of Competitive Advantage, notably the Diamond Model, explains why some countries or areas excel in specific industries. The model describes four main factors, which interact dynamically to either foster or hinder competitive advantage. These determinants are factor condition, demand condition, rivalry, and supporting industries (Davies & Ellis, 2000).

In discussing the Porter's Theory of Competitive Advantage in e-business sector we must consider the 4 primary determinants mentioned above. The variables we have chosen to conduct the research are online sales volume, internet penetration rate, number of e-business firms and number of e-business suppliers. These variables are strictly connected to with the porter's diamond model.

This theory observes and analyses 4 major factors within a particular industry and resolves why a particular industry thrives in a certain country or conversely. Pei-Hsuan Tsai et al. applied the Porter's Diamond Model to analyze best alternative in Taiwan's Solar Photovoltaic Industry. He used VIKOR method (Tsai et al., 2021).

Moreover, Minjing Peng and Min Liang also applied Porter's Diamond Model in their study "Regression Analysis of the Impact of Guangdong Province's Tertiary Industry on Export Trade Based on the Diamond Model" to check the stationarity of some variables by implementing ADF test and Co-Integration test (Peng & Liang, 2021).

3.2.1 Justification of Using Time-series and MCDM

The selection of VIKOR, TOPSIS, unit root test, co-integration test, and Granger causality test for assessing Bangladesh's e-business sector is methodologically justified by their complementing capabilities in meeting decision-making and time-series analytical needs. The use of VIKOR and TOPSIS, widely recognized as strong MADM approaches, is critical for rating and evaluating the performance of different years or scenarios in the sector based on several competing factors, such as competitiveness, growth potential, and infrastructure adequacy. These strategies optimize decision-making by balancing proximity to ideal solutions with compromise options (Chatterjee & Chakraborty, 2016b; Dedania et al., 2015b, 2015a; Opricovic & Tzeng, 2004; Shekhovtsov & Salabun, 2020; Tsai et al., 2021; Wei et al., 2020; Zeng et al., 2019).

Simultaneously, the unit root and co-integration tests provide a robust econometric framework for investigating the stationarity of time-series data and detecting long-term equilibrium correlations among key e-business variables such as IPR, OSV, and NEF. Finally, the Granger causality test provides insights into the causal dynamics of these variables, allowing for the discovery of bidirectional or unidirectional influences on sectoral competitiveness. These technologies work together to give a comprehensive framework for analyzing the complex interaction of factors driving Bangladesh's e-business sector, providing statistical rigor as well as actionable insights (Peng & Liang, 2021; Shojaie & Fox, 2021).

Hence, the theory Porter's Theory of Competitive Advantage aligns with this research most accurately.

3.3 Data Sources and Collections

The data for this study were gathered exclusively from secondary sources available online. Reputable websites, such as well-known news outlets and openly accessible online databases, provided free and easily accessible datasets eg. Statista, Datareportal, various notorious newspapers. Relevant data on e-business indicators, including online sales volume, internet penetration rates, and other economic measures, was supplied by these sources. Cost considerations and the viability of acquiring accurate, varied, and current information from reputable sources were the main factors in the decision to rely on secondary data. This method complied with ethical guidelines for data use while guaranteeing thorough coverage of the

variables required for the study’s analysis. Relevance, accuracy, and alignment with the study’s goals were given top priority during the data collection procedure.

The data is reserved in an excel sheet and a visualization of the data set is given as follows by a matrix where “d” represents each observation or rows and “N” represents each variable. The matrix illustrates the data set as a whole including population growth rate, change in every rate, every variables, etc.

$$X = \begin{bmatrix} x_1^1 & x_2^1 & x_3^1 & \cdots & x_N^1 \\ x_1^2 & x_2^2 & x_3^2 & \cdots & x_N^2 \\ x_1^3 & x_2^3 & x_3^3 & \cdots & x_N^3 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ x_1^d & x_2^d & x_3^d & \cdots & x_N^d \end{bmatrix}$$

The matrix “X” depicts the dataset all the indicators inclusive (Year, Quarters, Market_Size_mln(OSV), Internet_Penetration_Rate(IPR), Change_Rate_in_Internet_Users(%), Population_Using_Internet(%), Population_in_Bangladesh, Change_in_Population_Rate(%), Number_of_Ebusiness_Firms).

Any illustrations or calculations are done after based on this data set.

3.4 Research Flow Chart

A firm and crystalized flow-chart is shown for a better understanding how this research is conducted. Each steps has been inferred with graph to elucidate every steps of this thesis in the figure “Flow-Chart of Thesis”.

Flow-Chart of Thesis

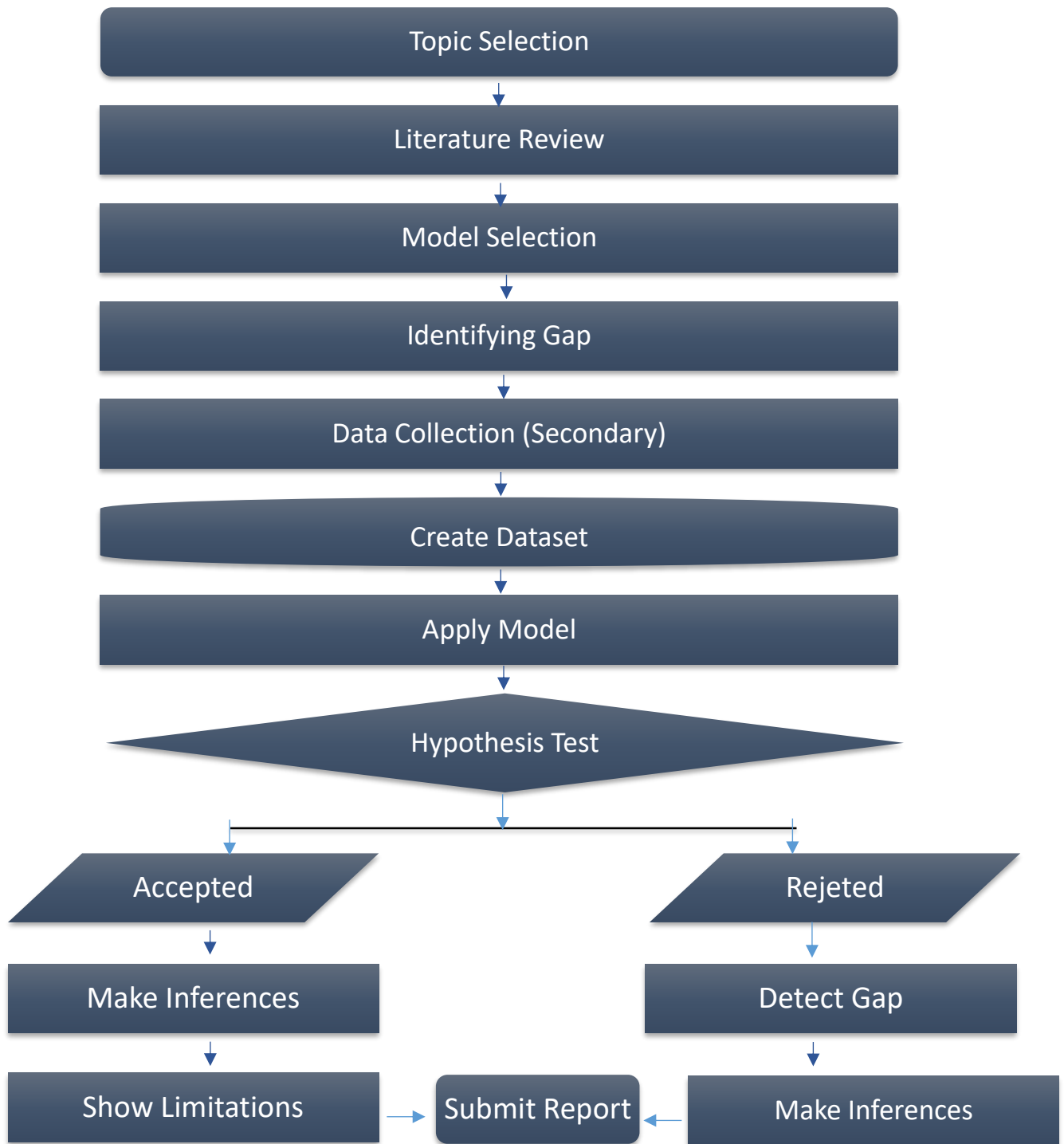


Figure: 3.1

3.5 Data Processing Method

The method of data processing of this research paper is shown below:

3.5.1 Granger Causality Test:

The Granger causality test is a statistical technique for figuring out whether one-time series may predict another. By determining if historical values of one variable provide information that aids in predicting future values of another, it investigates the cause-and-effect relationship between variables. In e-business research, this approach is especially useful for fulfilling correlations between internet traffic, customer behavior, and sales performance. The Granger causality test is a statistical technique for figuring out whether one time series may predict another. By determining if historical values of one variable provide information that aids in predicting future values of another, it investigates the cause-and-effect relationship between variables. In e-business research, this approach is especially useful for fulfilling correlations between internet traffic, customer behavior, and sales performance(Shojaie & Fox, 2021).

Key steps in Granger Causality Test

1. Specify a bivariate regression model where the dependent variable Y (e.g., e-business metric like sales) is regressed on its own lagged values and the lagged values of the predictor X (e.g., digital traffic or online engagement).

$$Y_t = \alpha + \sum_{i=1}^p \beta_i Y_{t-i} + \sum_{j=1}^q \gamma_j X_{t-j} + \epsilon_t$$

- a. Where p and q represent the lag lengths determined by information criteria, and ϵ_t is the error term.
2. Hypothesis Testing:
 - a. Null Hypothesis (H_0): X does not Granger Cause Y .
 - b. Alternate Hypothesis (H_1): X Granger-Cause Y .
 3. Perform F-tests on the coefficients of the lagged values of X . If the test statistic is significant (p -value < 0.05), reject H_0 and conclude that X Granger-causes Y .
 4. Repeat in Reverse: Conduct the test with X as the dependent variable to check for bidirectional causality. This helps to establish if the causation is unidirectional or mutual.

Implication Granger Causality in E-business

Finding predictive correlations in e-business data is aided by the Granger causality test. Knowing these causal linkages can help you make decisions by pointing out factors that affect important results, including how advertising influences customer acquisition or how online engagement indicators forecast future sales.

3.5.2 Unit Root Test:

The unit root stationarity test of data variables is a crucial procedure since its goal is to eliminate the false regression and false correlation issues brought on by unstable data to the model.

For data fulfilling, time series stationarity is crucial. Time series data instability can provide misleading correlations between independent variables, which can distort the model, or it can lead to the failure of the conventional t-test. Consequently, to ascertain whether the data is stationary by determining whether the data has a unit root, a unit root test is required. For the data, the following protocols have been set up:

$$y_i = ay_{i-1} + u_i, u_i \sim IID(0, \sigma^2)$$

$$y_i = ay_{i-1} + u_i + u, u_i \sim IID(0, \sigma^2)$$

$$y_i = ay_{i-1} + u_i + u + \beta t, u_i \sim IID(0, \sigma^2)$$

In formula (1) — (3), $u \sim IID(0, \sigma)$ $y = 0$. Where μ is the displacement term and βt is the time trend term. For the unit root test of time series y in the above model, the null hypothesis and the alternative hypothesis are respectively:

$$H_0: a = 1;$$

$$H_1: a < 1;$$

The test principle states that the null hypothesis is accepted and indicates that the data are non-stationary if the degree of freedom (DF) value is greater than or equal to the critical value. The null hypothesis is rejected, suggesting that the system is stable, if the degree of freedom value is less than the critical value.

For the Unit Root Test, we will be using the Augmented Dickey-Fuller Test, using the regression model as below:

$$\Delta Y_t = \alpha + \beta t + \gamma Y_{t-1} + \sum_{i=1}^p \delta_i \Delta Y_{t-i} + \epsilon_t$$

3.5.3 Cointegration Test

A co-integration test can be used to build a plausible model in the event of unstable time series data. The goal of the cointegration test is to obtain the long-term linkage trend by linearly combining the first-order integrated variables that are now available for examination. This eliminates the random trend in the variables. There are several uses for EG-ADF detection nowadays. The following are the primary steps in EG-ADF detection:

$$y_t = \gamma_0 + \gamma_1 x_t + \epsilon_t$$

$$e_t = y_t - (\hat{\gamma}_0 + \hat{\gamma}_1 e_t)$$

$$\Delta e_t = \eta e_{t-1} + \sum_{i=1}^m \lambda_i \Delta e_{t-1} + \epsilon_t$$

$$\Delta e_t = \alpha + \eta e_{t-1} + \sum_{i=1}^m \lambda_i \Delta e_{t-1} + \epsilon_t$$

$$\Delta e_t = \alpha + \beta_t + \eta e_{t-1} + \sum_{i=1}^m \lambda_i \Delta e_{t-1} + \epsilon_t$$

The hypothesis that will be calculated through this co-integration test would be:

H₀: There is no co-integration (no long-term relationship) among the variables.

H₁: Co-integration (one or more long-term relationships) exists among the variables.

$$\Delta Y_t = \Gamma Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \epsilon_t$$

3.5.4 Vikor Analysis

A multi-criteria decision-making technique called VIKOR (Vlsekriterijumska Optimizacija I Kompromisno Resenje) analysis focuses on ranking and choosing from a collection of alternatives when there are competing criteria. When several criteria need to be optimized, it is very helpful in

identifying compromise alternatives that are closest to the ideal answer. A compromise ranking is generated by minimizing the maximum group regret, determined by how far each alternative deviates from the best and worst outcomes after each alternative is assessed against criteria weights in VIKOR analysis. The approach ranks the options by generating a Q-value using a utility measure (S) and a regret measure I. The VIKOR technique provides a compromise option that is both practical and the closest to the ideal, making it useful in difficult decision-making scenarios.

Key steps in VIKOR

1. Determine the best (f_j^*) and worst (f_j^-) values for each criterion across all alternatives.
2. Calculate the utility measure (S) and regret measure I.

$$S_i = \sum_{j=1}^n w_j \frac{f_j^* - f_{ij}}{f_j^* - f_j^-}$$

$$R_i = \max_j \left(w_j \frac{f_j^* - f_{ij}}{f_j^* - f_j^-} \right)$$

3. Compute the Q-value for each alternative, representing the compromise measure.

$$Q_i = vS_i - S^*S - S^* + (1 - v)R_i - R^*R - R^*$$

✓ Where:

- $S^* = \min_i S_i$
 - $S^- = \max_i S_i$
 - $R^* = \min_i R_i$
 - $R^- = \max_i R_i$
 - v is the weight for the strategy of maximum group utility (here $v=0.5$)
4. Rank the alternatives based on their Q-values with the lowest inferring the best compromise solution.

Implication of VIKOR Model

In e-business, VIKOR enables the evaluation of several factors that are essential to digital performance. By computing Q values, this approach offers a reliable means of ranking solutions according to how close they are to the ideal business criteria, striking a balance between

performance and efficiency. In e-business, VIKOR enables the evaluation of several factors that are essential to digital performance. By computing Q values, this approach offers a reliable means of ranking solutions according to how close they are to the ideal business criteria, striking a balance between performance and efficiency.

3.5.5 TOPSIS Test

Using a set of criteria, the TOPSIS (Technique for Order of Preference by Similarity to the Ideal Answer) analysis ranks options according to how near they are to the ideal answer. Each option in TOPSIS is assessed according to its distance from the negative ideal (worst possible) and proximity to the positive ideal (best possible) solutions. It provides a clear ranking by calculating a similarity score for each alternative using criteria weights. When a clear preference order between competing solutions with conflicting criteria is required, TOPSIS works particularly well.

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Key steps in TOPSIS Test

1. Normalize the decision matrix to scale values between 0 and 1.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}}$$

2. Using criteria weights, find the weighted normalized matrix w_j .

$$v_{ij} = w_j \times r_{ij}$$

3. Identify the positive ideal (A^*) and negative ideal (A^-) solutions.

$$A^* = \{max(v_{ij})|j \in J(benefit); min(v_{ij})|j \in J'(cost)\}$$

$$A^- = \{min(v_{ij})|j \in J(benefit); max(v_{ij})|j \in J'(cost)\}$$

4. Calculate the Euclidean distance from the ideal and anti-ideal solutions for each alternative.

$$D_i^* = \sqrt{\sum_{j=1}^n (v_{ij} - A_j^*)^2}$$

$$D_i^- = \sqrt{\sum_{j=1}^n (v_{ij} - A_j^-)^2}$$

5. Compute the relative closeness to the ideal solutions.

$$C_i^* = \frac{D_i^-}{D_i^* - D_i^-}$$

6. Rank the alternatives based on C_i^* , higher numbers signify a closer approach to the optimal solution.

Implications of TOPSIS Test

TOPSIS is helpful for decision-making in situations where balanced trade-offs are crucial since it ranks e-business strategies according to how close they are to ideal performance on a number of parameters.

3.6 Data Preparation and Processing

This study only uses secondary data that was gathered from publicly available internet sources. Key metrics pertinent to Porter's Diamond Model as applied to Bangladesh's e-business industry are included in the data, which spans the years 2018–2024. Each dimension of Porter's framework is represented by a specific variable, which is chosen from government publications, industry reports, reliable databases, and market research websites. These variables include online sales volume, internet penetration rate, the number of e-business firms, and e-business suppliers.

All acquired data is pre-processed, using normalizing procedures when necessary, to align various data types and scales in order to guarantee consistency and comparability. Using VIKOR and TOPSIS methodologies, this method enables accurate econometric analysis and trustworthy multi-criteria decision-making (MCDM) evaluations. In addition to promoting transparency, using

publicly accessible data shows that trade competitiveness may be evaluated in research settings with limited resources.

3.7 Summary of Methodology

This methodology evaluates trade competitiveness and e-business indicators in an organized manner utilizing the Granger causality, Unit Root, VIKOR, and TOPSIS tests. This method provides a comprehensive picture of the e-business environment in Bangladesh by combining econometric and MCDM methodologies. It also rates competitive alternatives and captures the dynamic causal linkages between variables. When combined, these techniques provide a strong foundation for strategic insight and well-informed decision-making on boosting e-business competitiveness.

3.8 Introduction of Data-Analysing Process

Using econometric and decision-making techniques, the analytical division methodically investigates the connection between trade dynamics and e-business performance metrics in order to uncover underlying trends and interdependencies. Important investigations include the Granger causality test, which looks at directional links between variables, and the unit root and co-integration tests, which guarantee the accuracy of time-series data. Furthermore, the e-business landscape's competitive elements can be prioritized according to the multi-criteria decision-making perspectives offered by VIKOR and TOPSIS studies. When taken as a whole, these analyses provide a thorough grasp of the ways in which particular e-business variables affect trade competitiveness, bolstering strategic insights for those involved in Bangladesh's e-commerce industry.

3.8.1 Porter's Diamond Model

American strategic management specialist Michael Porter proposed the diamond model (Porter's Five Forces Explained and How to Use the Model, n.d.). A technique for assessing a nation's or region's place in the global economy is Porter's diamond model theory, which may be used to compare the competitiveness of different areas or sectors of the economy. According to the Porter Diamond Model Theory, a country's internal economic environment—which primarily consists of the following fundamental elements—influences competitive advantage. These elements include production factors, demand conditions, enterprise strategy, enterprise institutions, competitive

factors, opportunities, and government behavior. The four components of the production factor, demand condition, company strategy, enterprise organization and competitiveness factor, and applicable industry factor are the critical variables in the relationship of numerous aspects in Porter's diamond model, as seen in **Figure 3.2**

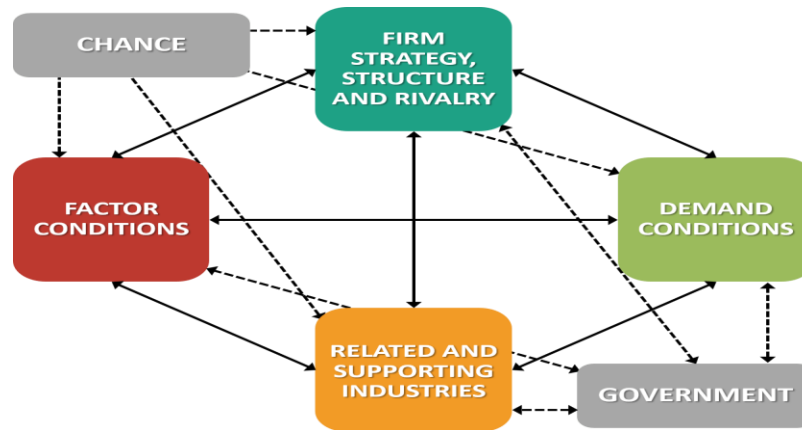


Figure 3.2

3.8.1.1 Key Factors of Porter's Diamond Model

Factor Condition

The first component of the diamond is the nation's ownership of production factors. According to the factor proportions hypothesis (Heckscher-Ohlin), each country has a relative abundance of specific factor endowments. Porter's diamond model distinguishes between basic and advanced components (*Porter's Diamond Model, Factor Conditions*, n.d.).

- These include the infrastructure, technology, capital resources, and people resources that are required for manufacturing. Porter makes a distinction between advanced factors (such specialized knowledge and technological infrastructure) and basic factors (like natural resources and unskilled labor).
- When countries invest in advanced elements instead of depending only on natural endowments, they gain a competitive edge. For instance, Germany's emphasis on engineering education has helped it become the world leader in the equipment and automotive industries.

- Relevance: Competitive industries can be built on a solid foundation by nations that produce distinctive, specialized resources.

Demand Condition

Porter's Diamond Model defines demand circumstances as home market demand for a specific product or service. These are determined by consumer demographics, the number of client segments, and how they are distributed. High demand forces a firm to constantly update its product line up and innovate in order to achieve a competitive advantage (Roy, 2021).

Demand circumstances describe the nature and magnitude of domestic demand for an industry's goods and services. The major features are the strength and sophistication of domestic customer demand. Porter (1990b, pp. 79–80) contends that businesses are most sensitive to the demands of their closest clients. Thus, local market demand is very important in influencing the characteristics of the companies' products (Porter's Diamond Model, Factor Conditions, n.d.).

- The competitiveness of an industry is determined by the type of domestic demand for its goods and services. Local clients are sophisticated and picky, which forces businesses to innovate and raise standards.
- Japan's early adoption of high-quality electronics, for instance, encouraged innovation in businesses such as Sony and Panasonic.
- Relevance: Businesses are better equipped to fulfil the demands of global markets when there is a high level of local demand, which encourages creativity and responsiveness.

Related and Supporting Industries

A business environment that includes connected suppliers, competitors, and complementary enterprises is seen to be extremely beneficial to an industry's ability to gain a competitive advantage. An industrial cluster is defined as a spatial concentration of companies, suppliers, and supporting firms in a certain place (Porter 2000, p. 254) (*Porter's Diamond Model, Factor Conditions*, n.d.).

- Strong, internationally competitive suppliers or allied industries frequently assist competitive industries, allowing them to flourish.

- For instance, Silicon Valley's digital ecosystem flourishes because of its network of suppliers, financiers, and research institutions, and Italy's fashion industry benefits from top-tier textile producers.
- Relevance: Industry cooperation promotes efficiency and innovation, resulting in a network of competitive advantages that reinforce one another.

Firm Strategy, Structure and Rivalry

This diamond aspect is related to company-based theories of internationalization, which focus on individual corporate actions. National context and conditions have a significant impact on how businesses are formed, established, and managed, as well as the character of domestic competition (Porter 1990b, p. 81) (*Porter's Diamond Model, Factor Conditions*, n.d.).

- The nature of domestic rivalry and the circumstances surrounding the formation, organization, and management of businesses influence competitiveness. Businesses are forced to innovate, cut expenses, and boost efficiency because of fierce local competition.
- For instance, the fierce competition between German automakers (such as BMW, Mercedes-Benz, and Volkswagen) has fuelled improvements in both quality and technology.
- Relevance: Firms are encouraged to aim for leadership in global marketplaces by competition and well-organized systems.

3.9.1.2 External Factors of Porter's Diamond Model

Government

The government plays an important role in supporting national innovation by creating a favorable environment for competitive advantage. Governments promote technical progress and economic growth through targeted policies such as tax breaks, R&D funding, and infrastructure development. Thailand's uncertain political environment limits consistent policy implementation and economic success, whereas Singapore has a stable political framework that encourages innovation and entrepreneurship (Wonglimpiyarat, n.d.).

- Governments can significantly contribute to the creation or enhancement of competitive environments by making investments in infrastructure, innovation, and education. They also impact industry through trade policies and regulations.

- For instance, South Korea's chaebol system, which the government backed, encouraged the growth of multinational corporations like Samsung and Hyundai.

Chance Events

As previously stated, the diamond model's fundamental premise is that a competitive advantage can be achieved. As a result, nations can gain a competitive advantage by incrementally enhancing each of the diamond's parts. In this regard, it is vital to stress that government interventions must be evaluated in terms of their impact on local corporate operations, because the diamond model's underlying assumption is that "firms, not nations, compete in international markets" (Porter 1990a, p. 33) (*The Role of Chance and Government, Evaluation of the Diamond Model*, n.d.).

- Competitive dynamics can be altered by unforeseen outside events like natural disasters, political upheavals, or technology advancements.
- For example, the competitive environment for established sectors was drastically changed by the internet's accidental rise to prominence.

Choosing and defining the pertinent variables that indicate e-business activities and trade outcomes is the first step in the study (*Location, Competition, and Economic Development: Local Clusters in a Global Economy - Michael E. Porter, 2000, n.d.; Piano • Client Dashboard, n.d.; Porter, 1996, 1996*). The following are the main e-business variables for this study:

3.8.2 Defining & Variable Settings

3.8.2.1 For Granger Causality & Unit-Root Test

The model was constructed from 2018 to 2024, and 7 years of data for analysis.

Explained Variable

The number of online sales OSV(Y): The competitiveness of e-business is heavily dependent on the Online Sales Volume. The larger the online sales volume, the stronger the country's e-business sector.

Explanatory Variables

Regarding the elements of Porter's Diamond Model, we have considered IPR(X_1) as a factor condition. Lastly, the NEF(X_2) is regarded as a rivalry.

Internet Penetration Rate (IPR)

Definition: The proportion of the population with internet access and usage.

Pertinence to the Diamond Model of Porter

Factors Condition: One of the primary factors influencing a region's technological capabilities and infrastructure is the level of internet penetration. Higher internet penetration rates indicate greater access to digital resources and technologies, which are essential for the growth of e-businesses.

Online Sales Volume (OSV)

Definition: The total amount or value of products and services sold online over time.

Pertinence to the Diamond Model of Porter

Demand Condition: The number of online sales indicates the level of demand for e-business services in the industry. A strong demand environment is indicated by high sales volume, which pushes companies to develop and enhance their online services.

Number of E-Business Firms (NEF)

Definition: The total number of businesses engaged in electronic commerce.

Pertinence to the Diamond Model of Porter

Firm Strategy, Structure, and Rivalry: The number of e-business companies reflects the degree of industry competitiveness as well as the strategic stances taken by companies operating there. Many businesses propose that a competitive atmosphere fosters efficiency and creativity.

For a detailed study, we have only worked with 3 variables regarding Porter's Diamond Model. A concise yet detailed description of the variables are provided in the table follows, which comprises each variables' linkages with Porter's Diamond Model along with cogent justifications.

Table: 3.1: Variable Table

Porter's Diamond Model Determinants	Variables	Definition	Justification
Factor Condition	Internet Penetration Rate (IPR)	The proportion of the population with internet access	Represents the technological infrastructure crucial for enabling e-business operations and accessibility, driving growth and innovation.
Demand Condition	Online Sales Volume (OSV)	Total value of products sold online	Indicates the level of consumer demand for e-business services, fostering competitiveness and innovation to meet high customer expectation
Firm Strategy, Structure, and Rivalry	Number of E-Business Firms (NEF)	Count of firms engaged in e-commerce	Reflects the competitiveness intensity within the e-business sector, motivating firms to innovate and enhance operational efficiencies.

3.8.2.1.1 Model Construction

Every component of the diamond model is taken into account while setting the explanatory variables. The Online Sales Volume is significantly impacted by all three of these explanatory variables, or the explained variables. Therefore, the model is set as follow:

$$\ln Y = C + \alpha_1 \ln X_1 + \alpha_2 \ln X_2 + \eta$$

Granger Causality Test

A Granger causality test will be used to investigate the directional link between the e-business variables. This test is essential for figuring out whether there is a causal relationship between two time-series variables by predicting one another. Granger causality specifically examines whether past values of one variable can statistically significantly predict another variable beyond those of the original variable.

Unit Root Test

It is crucial to test for stationarity to ensure that the variables chosen are appropriate for time series analysis. Determining whether the variables are stationary or include unit roots is important since non-stationary data might produce erroneous regression findings. The e-business variables will be tested for unit roots using the Augmented Dickey-Fuller (ADF) test.

Every variable will be subjected to the ADF test on its own, with the null hypothesis being that each variable has a unit root, or is non-stationary. A rejection of the null hypothesis would suggest that the variable is stationary. Before moving on to the following stages, differencing techniques will be used to ensure stationarity if the variables are discovered to be non-stationary.

Utilizing Co-Integration Tests

Co-integration tests are then used to examine the long-term linkages between the e-business variables after stationarity has been established. Co-integration tests indicate if a set of non-stationary series is co-integrated, which suggests that even while each series is non-stationary on its own, they have a shared long-term equilibrium relationship.

The quantity and existence of co-integrating vectors among the e-business variables will be ascertained using the Johansen co-integration test. The test will assist in determining consistent, long-term correlations between variables like trade volume, website traffic, and online sales volume. The long-term movement of these variables together is indicated by the presence of co-integration, which sheds light on their interdependence and overall influence on trade dynamics.

Implementing Regression Analysis

Regression analysis will be performed using the long-term associations that were found through the co-integration tests in order to measure the effect of e-business operations on trade outcomes. In particular, models that explain how changes in e-business factors affect trade volume and export growth rate will be constructed using stepwise regression.

In stepwise regression, the most important variables impacting trade outcomes are identified by adding or deleting predictors according to statistical criteria. Using this approach, one can create a parsimonious model that strikes a balance between explanatory power and complexity. Regression analysis will yield coefficients that express the relative importance of each e-business variable, providing specific proof of the role that digital activities play in trade competitiveness.

Why both Unit-Root and Granger-Causality Test?

Using both methodologies improves the reliability and validity of the analysis. While the unit-root test assures that the data is steady, hence avoiding misleading regressions, the Granger causality test reveals the directional links between variables over time. This dual approach assures that:

- **Comprehensive Analysis:** By addressing both stationarity and causation, the integrated application provides a strong foundation for time-series analysis, lowering the danger of making incorrect conclusions.
- **Consistency in Results:** Ensuring stationarity using unit-root tests improves the reliability of Granger causality conclusions, allowing for a better understanding of temporal interactions between variables.

3.8.2.2 For TOPSIS & VIKOR Model

Further we will use MCDM using VIKOR & TOPSIS method. Opricovic (1998) developed VIKOR based on the compromised programming used here (Serafim Opricovic a, 2003). This method uses the class distance function based on the aspiration and worst levels solution and then orders the results (Shouzhen Zenga, 2019).

The variables would be the same as unit root test. Internet Penetration Rate (IPR), Online Sales Volume (OSV), Number of E-Business Firms (NEF).

The applicability of the TOPSIS and VIKOR techniques for assessing performance across a variety of sometimes incompatible criteria in a dynamic setting such as e-commerce justifies their use in this study. Although cross-sectional data is typically analyzed using these techniques, their versatility in time-series research offers a novel way to evaluate the relative performance of e-commerce variables across time.

TOPSIS: Technique for Order of Preference by Similarity to Ideal Solution

TOPSIS is very beneficial in this situation since it ranks options (years in this case) according to their distance from an ideal and an anti-ideal solution. The technique computes a closeness coefficient (C), which measures how close each year's performance is to the best situation. The argument for utilizing TOPSIS includes (Dedania et al., 2015b; Opricovic & Tzeng, 2004; Shekhovtsov & Sałabun, 2020; Zeng et al., 2019):

1. Multi-Criteria E-commerce performance is measured using a variety of measures, including market size (OSV), internet penetration rate (IPR), and the number of e-business firms (NEF). TOPSIS efficiently aggregates various indicators by weighing their respective value.

2. **Dynamic Year Comparison:** By standardizing the data, TOPSIS enables meaningful comparisons between years using different scales or units.
3. **Ease of Interpretation:** The closeness coefficient reduces complex data to a single score, making it easier to identify the year with the best performance.

VIKOR: Multi-Criteria Optimization and Compromise Solutions

VIKOR, on the other hand, rates years by identifying a compromise option that reduces discontent while increasing usefulness across all parameters. Its inclusion in this analysis is justified as follows (Chatterjee & Chakraborty, 2016b; Wei et al., 2020; Zeng et al., 2019) :

1. **Trade-Off Management:** VIKOR considers trade-offs between criteria, weighing the influence of each indicator (for example, high OSV vs. mild IPR).
2. **Compromise Ranking for Strategic information:** The utility measure (S) and regret measure (R) offer levels of information, guaranteeing that the study considers both collective and individual dissatisfaction with a year's performance.
3. **Sensitivity to Relative Importance:** The flexibility to modify the weights of criteria coincides with the dynamic priorities of e-commerce (for example, IPR may become more important in later years due to digital penetration).

Adaptation to Time-Series Analysis:

Although these methods are often employed for alternative-based decision-making, their adaption to time-series data in this study allows:

- **Temporal Evaluation of Performance:** By treating each year as an alternative, we may assess performance patterns and determine the best-performing year in the context of changing e-commerce dynamics.
- **Data-Driven Insights:** Using time-series data ensures that the rankings are based on real-world performance measures and provides practical insights into how e-commerce competitiveness has changed over time.

Why both TOPSIS and VIKOR?

Using both methods improves robustness and cross-validates the results. While TOPSIS focuses on proximity to perfect solutions, VIKOR considers the need to balance collective utility and individual happiness. This dual approach assures that:

- **Comprehensive Analysis:** The combined application reduces potential biases from utilizing a single method, resulting in a more comprehensive knowledge of e-commerce success.
- **Consistency in Rankings:** Similar rankings across methodologies increase trust in the findings, while variances identify areas that require additional examination.

3.9 Conclusion

The analytical approach used in this study provides a comprehensive evaluation of e-commerce performance in Bangladesh, including econometric and multi-criteria decision-making (MCDM) techniques. The use of Granger causality, unit-root tests, and co-integration tests ensures a thorough knowledge of the temporal dynamics and interdependence of key variables such as market size, internet penetration rate, and number of e-business businesses.

By combining the VIKOR and TOPSIS models, the study closes the gap between theoretical frameworks and real decision-making. These algorithms effectively assess e-commerce's annual performance, highlighting the best-performing year through balanced trade-offs between competing criteria. The use of both methodologies improves the trustworthiness of the results and provides complementary insights into the sector's competitive dynamics.

The findings not only highlight significant historical patterns, but also emphasize the importance of specific drivers such as internet penetration and business proliferation in driving e-commerce growth. Furthermore, the strategy provides policymakers and business stakeholders with actionable insights, allowing them to make strategic decisions to maintain and improve competitiveness in the growing digital economy.

Finally, this analysis shows how integrating econometric techniques with advanced decision-making methodologies can result in a more nuanced view of e-commerce success over time. The findings provide a solid platform for future research and strategic actions aimed at increasing e-business growth and competitiveness in Bangladesh.

Chapter IV: Analysis, Results and Discussions

4.1 Introduction of Results and Discussion

This section presents the findings of the study, offering valuable insights into the dynamics of e-business competitiveness in Bangladesh. The results, derived from econometric tests and advanced multi-criteria decision-making (MCDM) frameworks like VIKOR and TOPSIS, underscore the relationships between key variables and their influence on trade outcomes.

To enhance the robustness of the analysis, unit-root tests and co-integration tests were performed to ensure the stationarity of the data and to identify long-term equilibrium relationships among variables. The inclusion of the Granger causality test further evaluates the direction of influence between independent variables, such as internet penetration, and dependent variables, including online sales volume and overall e-business competitiveness.

This analytical framework bridges theoretical concepts with practical implications, illuminating the roles of e-business suppliers, firms, and digital adoption in shaping trade dynamics. By systematically interpreting the data and validating the proposed models, this section lays a foundation for informed strategies that can drive growth and innovation in the e-business sector.

Let us now delve into the findings and their implications, exploring the evolving landscape of digital trade in Bangladesh and how these tests reveal the underlying interactions between critical determinants.

4.2 Insights of Bangladesh

Bangladesh is a nation experiencing rapid economic development and digital revolution. It is one of the world's most densely inhabited countries, with a population of about 170 million. With 131 million users by the end of 2023, the nation has made impressive strides in internet usage, primarily due to mobile connectivity. This is a huge increase, accounting for more than 75% of all mobile device internet access (*Country's Internet User Base Grows to 131m at 2023 End | The Business Standard*, n.d.).

With a GDP of about \$460 billion in 2022, Bangladesh's economy has been booming and showing consistent growth. In 2022, the GDP per capita was \$2,688, which reflected rising living standards and incomes. Despite obstacles, the country's economy is supported by strong industries like remittances and textiles (*World Bank Open Data*, n.d.).

This rapid growth is accompanied by initiatives to update infrastructure and increase digital connectivity. Bangladesh's road towards becoming a digital economy is being shaped by its continued embrace of innovation and technology, which bodes very well for the future.

Some charts and graphs are shown here to advocate these data regarding Bangladesh. The information illustrated in this graph are collected from various online trusted sources. Links are also given below:

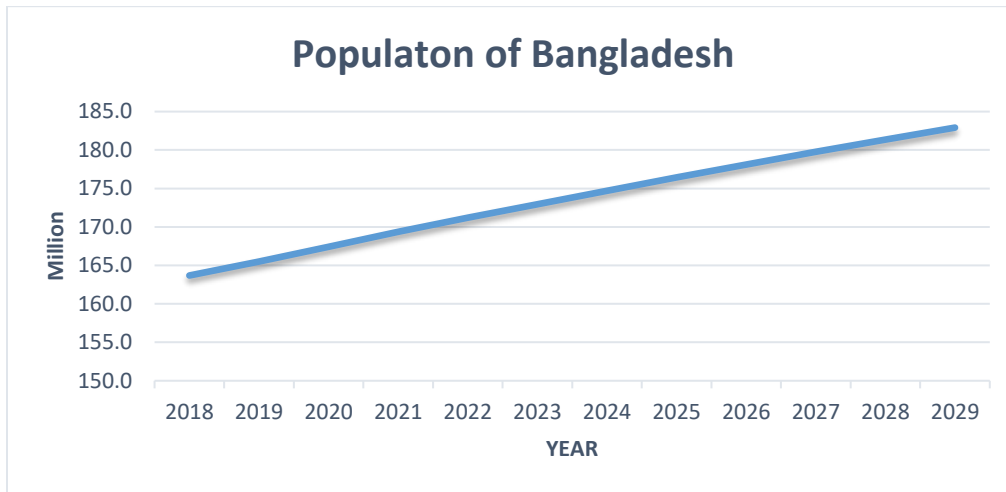


Figure: 4.1

The population of Bangladesh is shown in this chart. This data is collected from the macrotrends website(*Bangladesh Population 1950-2024*, n.d.) It has also been extrapolated where the quantity of population would reach from 2025 to 2029. From the line graph the observation is clear that there is an upward trend in population.

One of the most important factors or variables in this study is the Internet penetration rate, or the number of people in Bangladesh using the Internet now. These two charts demonstrate clear and concise data regarding it.

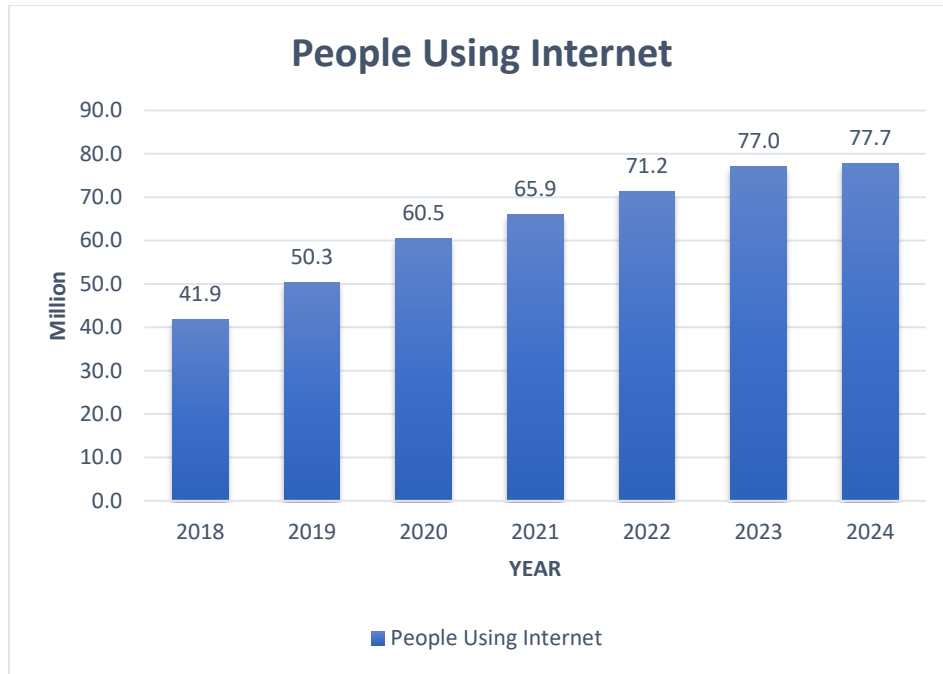


Figure: 4.2

The above table denotes how many people are using the Internet in Bangladesh. This table however infers how many people are using the internet including all ages. But it is crucial to know that how many individuals of median-aged are spending time in internet as they are the significant assets of a country. However, the median-age of Bangladesh has changed over time. Still this is a table below, which can demonstrate thoroughly the percentage of median-aged people expending time over internet.

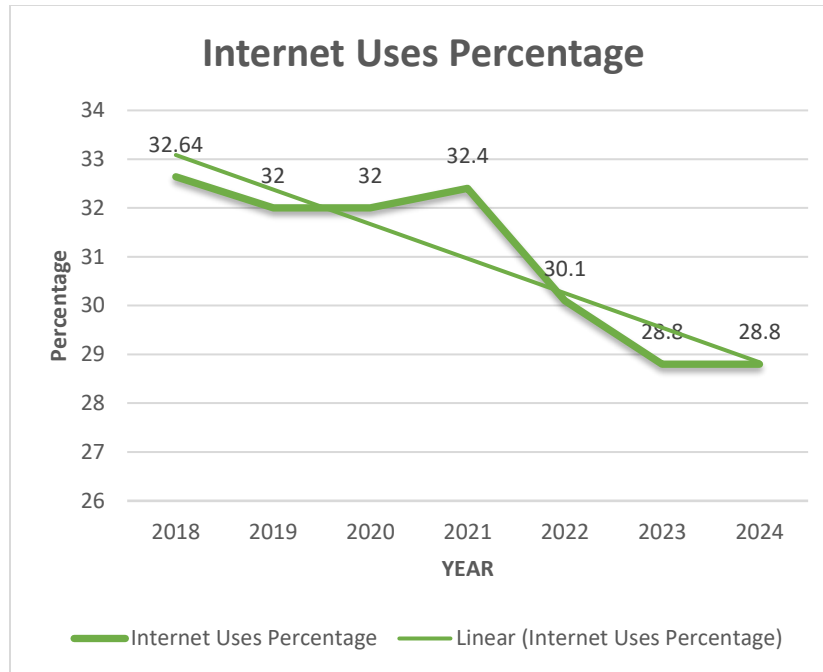


Figure: 4.3

Along with presenting the percentage of people who are using internet it is also need to be resolved the values of median age over time. A table is showed regarding that. The data is collected from free online websites (*Digital in Bangladesh — DataReportal – Global Digital Insights, n.d.*).

Table: 4.1: Table of Median Age

Year	Median Age
2018	27.10
2019	27.50
2020	27.60
2021	27.80
2022	27.30
2023	27.00
2024	27.30

Table 1 reveals insights about Bangladesh's median age over time. From the above table and charts, it can easily be elucidated that there has been an upward trend noticeable in the growth of the population and in the use of the Internet. There are also illustrations about the most searched queries and how much time is spent on average on which websites.

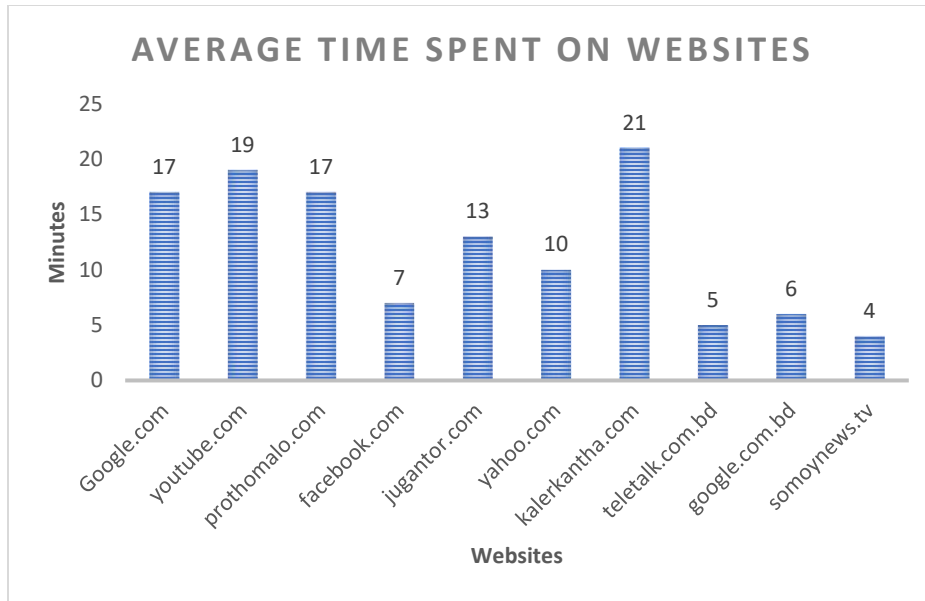


Figure: 4.4

This bar chart shows that how much time in minutes is spent on average on an particular website by Bangladeshi citizens. Along with this the information can also be found about the most searched queries. The queries shown in pie chart.

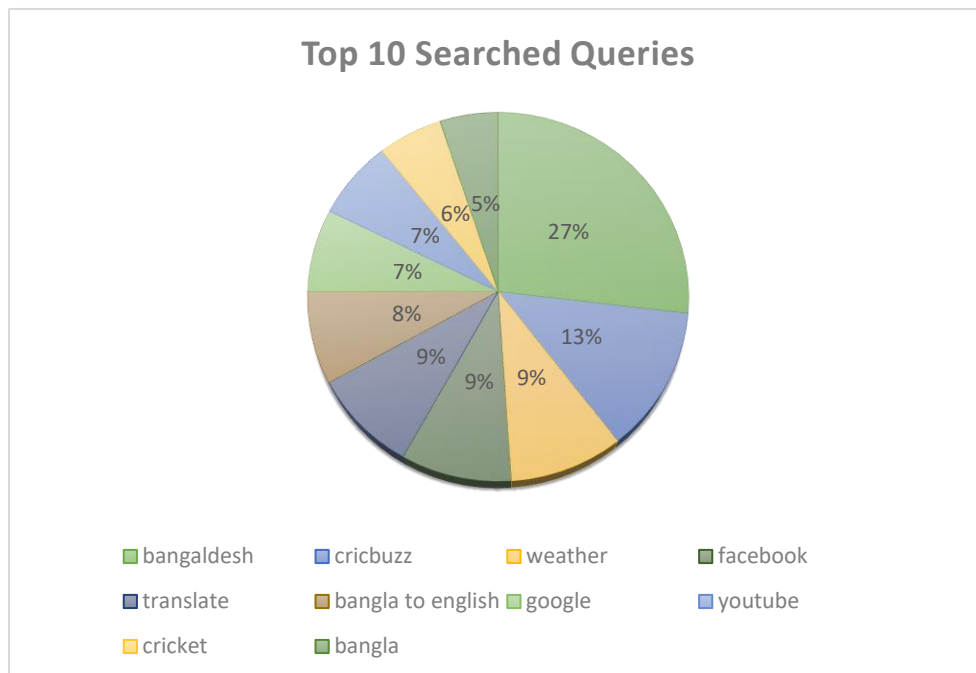


Figure: 4.5

The pie chart of illustration 5 deduces the information about the most searched queries. Note that the data for illustrations 4 and 5 were only collected for the 2024 year.

From the above discussion, it is visible that the users of the internet is thriving over Bangladesh. However, we also know that Facebook and Instagram control Facebook and Instagram 2 major social media platform covering a major proportion of Internet usage and from the perspective of Bangladesh a huge volume of e-commerce share through Facebook and Instagram marketplace. Therefore, we are presenting the usage of Facebook and Instagram in Bangladesh.

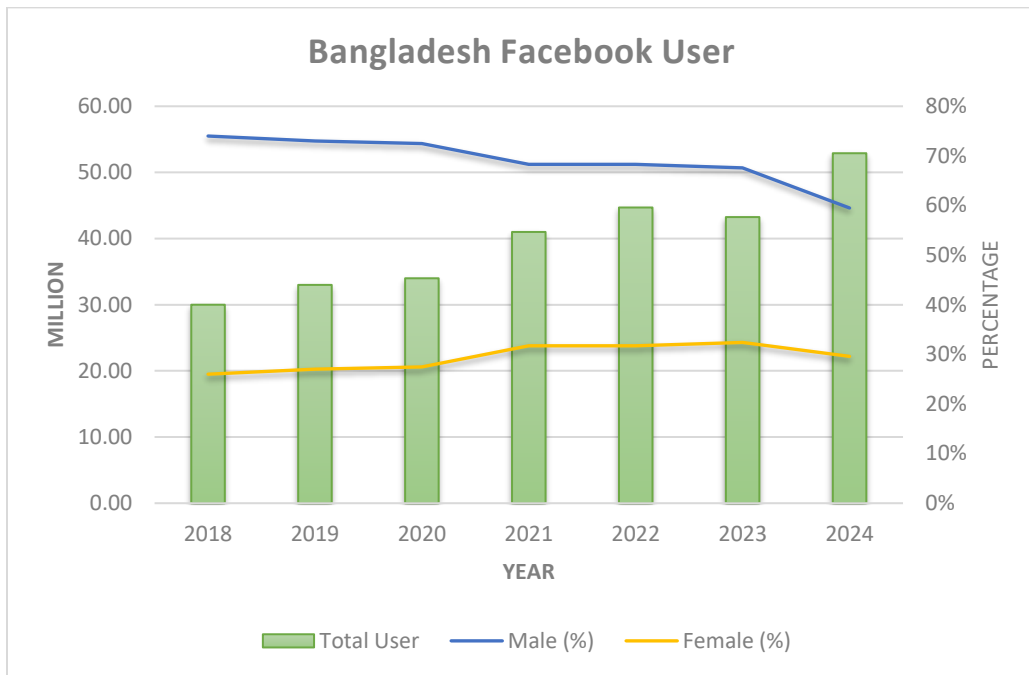


Figure: 4.6

The above illustration comprises data on Facebook users in Bangladesh. We also took account of Instagram users since it is the second-largest social media platform in Bangladesh.

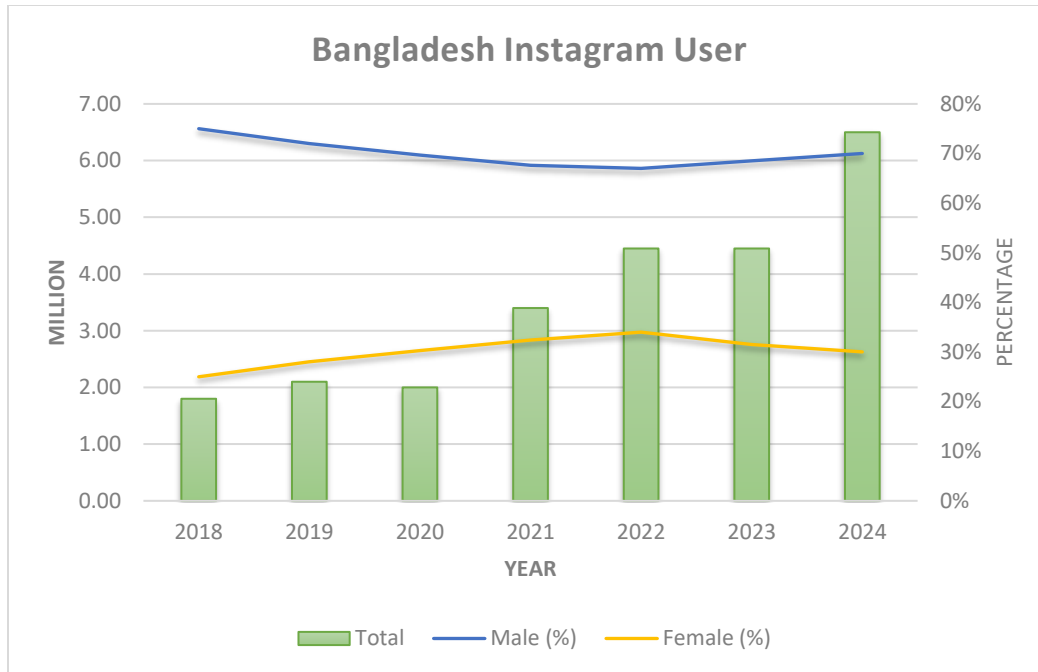


Figure: 4.7

Now, in terms of online sales volume, we considered the whole e-commerce market share in perspective. The data has been collected from various online websites, which are mostly reliable such as Statista, EcommerceDB, The Business Standard, etc.

If we see recent statistics, According to Dublin-based trade research firm ResearchAndMarkets.com, the size of the e-commerce market was approximately Tk56,870 crore in 2021 and is expected to reach approximately Tk1.5 lakh crore by 2026(*Bangladesh E-Commerce Sales to More than Double by 2026*, 2022). If we also further study from Statista it can be presumed that In 2024, the eCommerce market is expected to generate US\$6,800.00 million in revenue, also it is anticipated that revenue would rise at a pace of 12.84% per year (CAGR 2024-2029), with a projected market volume of US\$12,440.00m by 2029. By 2029, there will likely be 15.9 million users in the eCommerce market. It is assumed that the average revenue per user (ARPU) will reach US\$631.60. (*eCommerce - Bangladesh | Statista Market Forecast*, n.d.).

It is also been estimated by research and market that Bangladesh's e-commerce sector will expand by 9.33% annually to reach US\$6.9 billion by 2023. The e-commerce sector in Bangladesh has a promising medium- to long-term growth story(*Bangladesh Ecommerce Market Opportunities*

Report 2023: A \$9.2 Billion Market by 2027 Featuring Daraz Bangladesh, Chaldal, Evaly, Pickaboo, and Ajkerdeal, n.d.).

Lastly, we must take in considerations that most of the data of Bangladesh is not reliable and there are major scarcity in finding accurate data for research. So the CAGR was given we have distributed it from 2018 to 2029 and extrapolated the missing values by expecting that the CAGR would increase gradually. Moreover, there were also various information about the rate of CAGR, we took the lowest possible estimation to calculate.

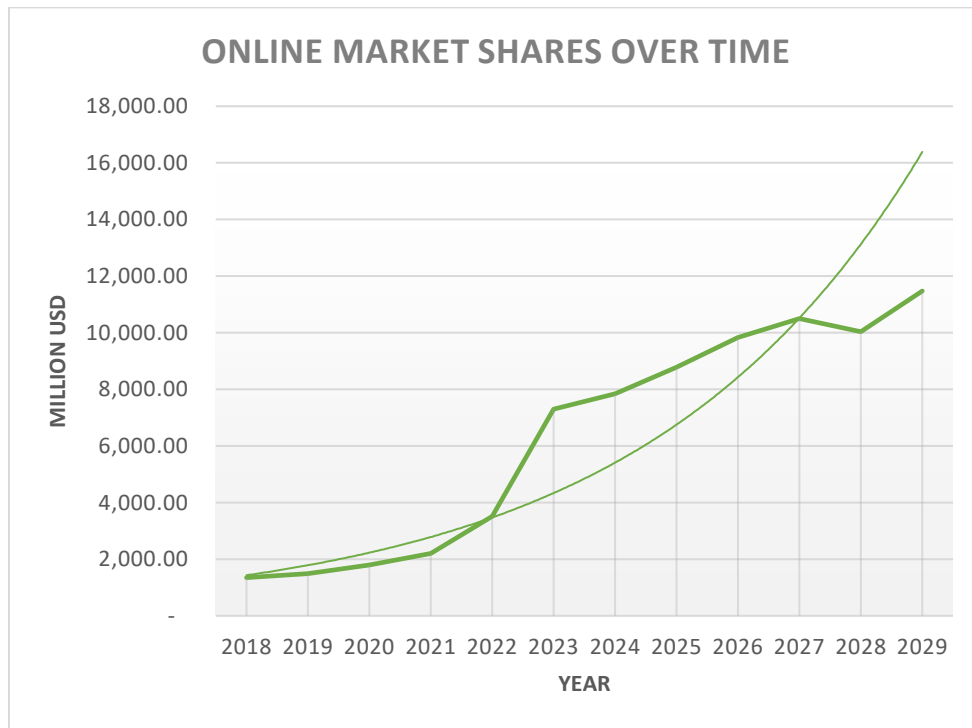


Figure: 4.8

We had the data to the year of 2024. We used the CAGR to predict further extrapolation.

From e-cab, we get to know that currently there are more than thousand ecommerce firms (NEF) in Bangladesh which was only 700 at the first quarter of 2018 (*E-CAB / e-Commerce Association of Bangladesh, n.d.*).

The rapid growth of e-business firms are shown below:

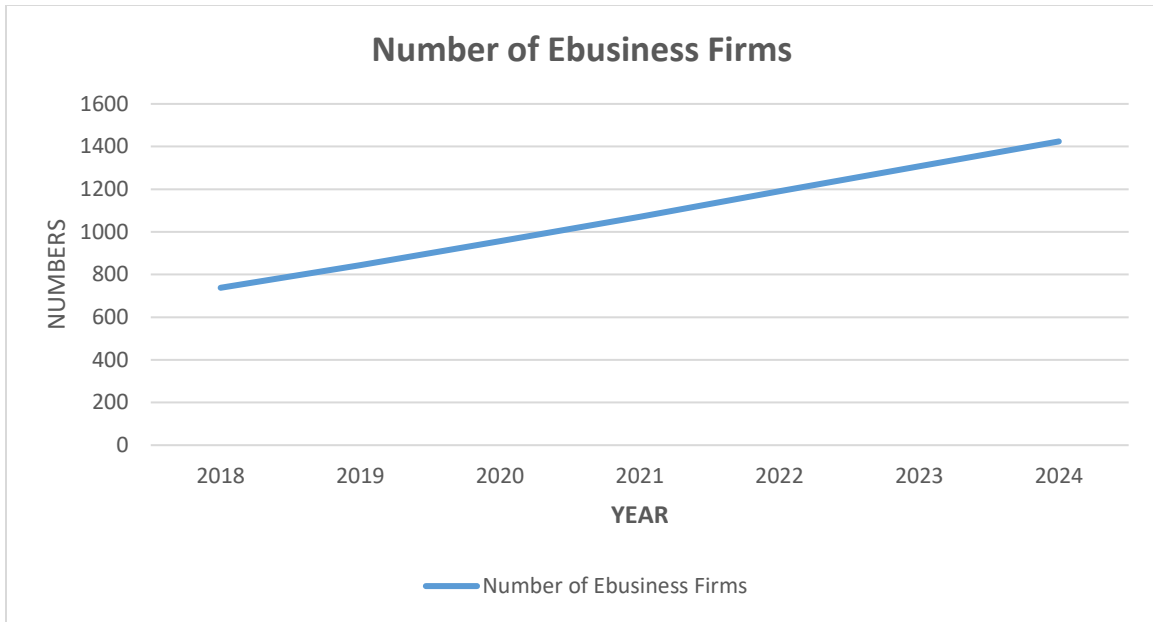


Figure: 4.9

4.3 Data Analysis

Although the hypotheses were mentioned above in the “Methodology” section, they were specified below:

For Unit-Root Test:

H_0 : The variables (OSV, NEF, and IPR) are “Stationary” meaning in a random specific time span the central tendency would be the same.

H_a : The variables (OSV, NEF, and IPR) are not “Stationary”.

For Co-Integration Test:

H_0 : The dependent variable OSV is not dependent on the rest of the independent variables NEF and IPR.

H_a : The dependent variable OSV is highly dependent on the rest of the independent variables NEF and IPR.

For Granger Causality Test:

- ✓ H_0 : The X (independent variable NEF, IPR) doesn't Granger Cause to Y (dependent variable OSV) meaning X time series cannot predict Y time series.
- ✓ H_a : The X is Granger Cause to Y.

Brief Explanation about the data set:

The dataset covers quarterly time-series data from Q1 2018 to Q4 2029, with a primary focus on analyzing the dynamics of Bangladesh's e-commerce market. The dependent variable, Online Sales Volume (OSV), denotes the total size of the e-commerce market. The independent variables are the Internet Penetration Rate (IPR), which measures the percentage of the population that uses the internet, and the Number of E-Business Firms (NEF), which represents the total number of registered e-commerce enterprises in the country.

While the data from 2018 to 2024 are historical records, the values from 2025 to 2029 are informed estimates based on data from credible online sources, such as journals and reports. This structured information is critical for studying trends, testing ideas, and modeling relationships in Bangladesh's rapidly developing e-commerce industry.

Table 4.2: Unit-Root test table

	Variable	ADF.Statistics	p.value	Stationarity
1	Market Size (OSV)	-1.9121	0.6061	Non-stationary
2	Internet Penetration Rate (IPR)	-22.429	0.01	Stationary
3	Number of E-business Firms (NEF)	-3.564	0.08301	Non-stationary

This table shows the ADF test statics, p-values, and stationarity conclusion for each variable.

Table 4.3: Con-Integration Test Results

	Test	Test.Statistics	X10.Critical.Value	X5.Critical.Value	X1.Critical Value	Co-integration
1	$r \leq 2$	0.78	6.5	8.18	11.65	No
2	$r \leq 1$	12.12	15.66	17.95	23.52	No
3	$r = 0$	37.63	28.71	31.52	37.22	Yes

This table presents the Johansen test results with test statics and critical values at different significance levels.

Table: 4.4 Granger Causality Test Results

	Casual.Relationship	F.Statistics	p.value	Significance
1	Internet Penetration Rate -> Market Size	2.4188	0.09426	Marginal
2	Number of E-business Firms -> Market Size	1.8843	0.1656	Not Significant
3	Market Size -> Internet Penetration Rate	3.9803	0.02141	Significant
4	Market Size -> Number of E-business Firms	1.8284	0.1759	Not Significant

This table summarizes the casual relationships between variables, showing F-statistics, p-values, and significance level.

Table: 4.5 Log differencing for OSV and second differencing for NEF

	Variable	ADF_Statistes	P_Value	Is_Stationary
1	OSV (Original)	-1.5	0.8	No
2	OSV (First Difference)	-3.5013	0.05225	No
3	OSV (Log + Difference)	-3.5578	0.04661	Yes
4	NEF (Original)	-0.5	0.9	No
5	NEF (First Difference)	1.2668	0.99	No
6	NEF (Log + Difference)	-2.8857	0.2211	No
7	NEF (Second Difference)	-7.5697	0.01	Yes

This table summarizes log differencing for OSV and second differencing for NEF.

Table: 4.6: Vector Error Correction Model

Coefficients:

	ECT	Intercept	OSV lag1	IPR lag1	NEF lag1	OSV lag2	IPR lag2	NEF lag2
OS V eq	- 0.33213 94	472.4325 63	0.120995 32	- 0.000952 2	17.44216 58	0.107453 72	0.001348 91	- 44.05736 2
IPR eq	- 1.14150 47	109965.1 78	0.294023 55	0.616678 21	- 203.5764 9	1.551048 84	0.291615 77	- 583.5767 4
NE F eq	- 0.00013 91	13.53953 03	0.000107 21	- 5.21341E -06	0.500326 32	0.000103 63	-8.325E- 06	0.436416 08

Table: 4.7: Co-integration Vector

	Co-integration Vector
OSV	1
IPR	0.000468496
NEF	-25.77663658

Table: 4.8: Model Fit

Statistic	Value
Sample Size	45
AIC	37
BIC	45
Degrees of Freedom	37

Table: 4.9: Final Regression Result

Variable	Coefficient	Std_Error	t_value	p_value	Variable
Constant	9.595	17.225	0.557	0.58	Constant
In(Internet Penetration Rate)	-1.587	1.355	-1.172	0.247	In(Internet Penetration Rate)
In(Number of E-business Firms)	3.81	0.989	3.853	0	In(Number of E-business Firms)
R-squared	0.921				R-squared

Table: 4.10: TOPSIS & VIKOR Analysis**Detailed Report of VIKOR and TOPSIS:**

Year	Quarter	OSV	IPR	NEF	TOPSIS_Closeness	TOPSIS_Rank	VIKOR_Utility	VIKOR_Regret	VIKOR_Index	VIKOR_Rank
2018	Q1	1313	39552894	700	0	28	1	0.333	1	28
2018	Q2	1336.64	40321270	725	0.282	22	0.977	0.332	0.987	27
2018	Q3	1360.71	41104573	751	0.286	21	0.953	0.331	0.973	26
2018	Q4	1385.22	41903093	777	0.048	27	0.930	0.330	0.960	25

20		141	4269	80							
19	Q1	0.16	0132	3	0.307	19	0.906	0.329	0.946	24	
20		143	4349	83							
19	Q2	5.56	1953	0	0.303	20	0.882	0.327	0.932	23	
20		146	4430	85							
19	Q3	1.41	8835	7	0.096	26	0.857	0.326	0.918	22	
20		164	4514	88							
19	Q4	8	1059	5	0.333	16	0.824	0.317	0.888	21	
20		167	4595	91							
20	Q1	7.68	9780	3	0.324	17	0.799	0.316	0.873	20	
20		170	4679	94							
20	Q2	7.89	3350	1	0.151	25	0.773	0.314	0.858	19	
20		173	4764	96							
20	Q3	8.64	2039	9	0.367	14	0.748	0.313	0.843	18	
20		207	4850	99							
20	Q4	7	6120	9	0.353	15	0.706	0.296	0.797	17	
20		212	4935	10							
21	Q1	4.66	4507	27	0.218	24	0.679	0.294	0.781	16	
20		217	5021	10							
21	Q2	3.42	7732	56	0.405	12	0.652	0.292	0.763	15	
20		222	5109	10							
21	Q3	3.29	6056	86	0.386	13	0.624	0.289	0.746	14	
20		227	5198	11							
21	Q4	4.32	9741	16	0.267	23	0.596	0.287	0.728	13	
20		232	5286	11							
22	Q1	6.51	5375	45	0.448	10	0.568	0.284	0.710	12	
20		237	5375	11							
22	Q2	9.89	5756	74	0.422	11	0.541	0.282	0.693	11	
20		243	5466	12							
22	Q3	4.51	1134	04	0.315	18	0.512	0.279	0.674	10	
20		690	5558	12							
22	Q4	0	1760	35	0.605	9	0.269	0.106	0.293	9	
20		709	5648	12							
23	Q1	8.29	1813	63	0.632	8	0.234	0.093	0.257	8	
20		730	5739	12							
23	Q2	2.27	6440	92	0.843	3	0.199	0.080	0.219	7	
20		751	5832	13							
23	Q3	2.12	5879	22	0.640	7	0.162	0.067	0.181	6	
20		730	5927	13							
23	Q4	0	0368	53	0.660	6	0.146	0.054	0.153	5	
20		750	6019	13							
24	Q1	9.78	1604	80	0.898	2	0.111	0.040	0.116	4	
20		772	6112	14							
24	Q2	5.59	7159	09	0.669	5	0.074	0.027	0.078	3	
20		794	6207	14							
24	Q3	7.61	7255	38	0.677	4	0.037	0.014	0.039	2	
20		817	6304	14							
24	Q4	6	2118	67	1	1	0	0	0	1	

Table: 4.11: Aggregate Ranking

Year	TOPSIS_Rank	VIKOR_Rank	Average_Rank
2024	3	2.5	2.75
2023	6	6.5	6.25
2022	12	10.5	11.25
2021	18	14.5	16.25
2020	17.75	18.5	18.125
2019	20.25	22.5	21.375
2018	24.5	26.5	25.5

4.3.1 Interpretation:

4.3.1.1 Unit Root (ADF Method):

Market Size (OSV)

- ADF Statistics: -1.9121
- p-value: 0.6061
- Stationarity: Non-stationary
- Summary: The null hypothesis of a unit root test that the OSV is stationary cannot be rejected at common significance levels (e.g. 1%, 5%, or 10%). This indicates that the OSV is non-stationary in its current form.

Internet Penetration Rate (IPR)

- ADF Statistics: -22.429
- p-value: 0.01
- Stationarity: Stationary
- Summary: The null hypothesis of a root is rejected at the 1% significance level. This means the Internet Penetration Rate (IPR) variable is stationary in its current form and does not require differencing or further transformations.

Number of E-business Firms (NEF)

- ADF Statistics: -3.564
- p-value: 0.08301
- Stationarity: Non-stationary

- Summary: The hypothesis of a unit root cannot be rejected at 5% significance level, but it is marginally significant at the 10% level. This indicates that NEF is likely non-stationary, though it may require further confirmation.

4.3.1.2 Co-Integration Test:

Test summary:

1. Hypothesis Tested

- r : The number of co-integration relationships.
- $r = 0$: No co-integrating relationships.
- $r \leq 1$: At most one co-integrating relationship.
- $r \leq 2$: At most two co-integrating relationships

2. Test Statistics and Critical Values:

- If the Test Statistic exceeds the critical value at a given significance level (10%, 5%, or 1%), we reject the null hypothesis of r co-integration relationships.

Row-by Row Interpretation

Row1: $r \leq 2$

- Test Statistics: 0.78
- Critical Values: 6.5 (10%), 8.18 (5%), 11.65 (1%)
- Co-integration: No
- Interpretation: The null hypothesis that there are at most 2 co-integrating relationships cannot be rejected. This indicates there are fewer than 2 co-integrating relationships among the variables.

Row 2: $r \leq 1$

- Test Statistic: 12.12
- Critical Values: 12.66 (10%), 17.95 (5%), 23.52 (1%)
- Co-integration: No

- Interpretation: The null hypothesis that there is at most 1 co-integrating relationship cannot be rejected. This suggests there are fewer than 1 co-integrating relationships among the variables.

Row 3: $r = 0$

- Test Statistic: 37.63
- Critical Values: 28.71 (10%), 31.52 (5%), 37.22 (1%)
- Co-integration: Yes
- Interpretation: The null hypothesis that there are no co-integrating relationships is rejected at the 10%, 5%, and 1% levels. This confirms the presence of at least one co-integrating relationship among the variables.

Overall Summary

- The results indicate one co-integrating relationship ($r = 1$) among the variables at the 1% significance level. This suggests that while the variables may be non-stationary individually, they maintain a long-term equilibrium relationship.

Implications

- The variables (e.g., OSV, IPR, NEF) share a long-term equilibrium connection, implying that changes in one variable may be systematically related to changes in the others over the long term.

4.3.1.3 Granger Causality Test:

Row by Row Interpretation

Row 1 IPR -> OSV

- F-Statistic: 2.4188
- P-value: 0.09426
- Significance: Marginal
- Interpretation: The p-value is marginally significant at the 10% level but not at the 5% level. This suggests weak evidence that changes in the Internet Penetration Rate Granger-

cause changes in Market Size. While not conclusive, there might be a potential predictive relationship that warrants further investigation.

Row 2: NEF -> OSV

- F-Statistic: 1.8843
- P-value: 0.1656
- Significance: Not Significant
- Interpretation: The p-value is not statistically significant, indicating no evidence that the Number of E-Business Firms Granger-causes changes in Market Size. NEF does not appear to predict OSV in this model.

Row 3: OSV -> IPR

- F-Statistic: 3.9803
- P-value: 0.02141
- Significance: Significant
- Interpretation: The p-value is significant at the 5% level, providing strong evidence that Market Size Granger-causes Internet Penetration Rate. This suggests that changes in the Market Size of e-commerce influence changes in Internet Penetration Rate, potentially indicating a feedback effect where market dynamics drive internet usage growth.

Row 4: OSV -> NEF

- F-Statistic: 1.8284
- P-value: 0.1759
- Significance: Not Significant
- Interpretation: The p-value is not statistically significant, suggesting no evidence that Market Size Granger-causes the Number of E-Business Firms. This indicates that changes in market size do not predict changes in the number of firms in this dataset.

Summary of Results

1. Significant Relationships: Market Size (OSV) Granger-causes Internet Penetration Rate (IPR) ($p = 0.021$).

2. Marginal Relationships: Internet Penetration Rate (IPR) weakly Granger-causes Market Size (OSV) ($p = 0.094$).
3. Non-Significant Relationships: Number of E-Business Firms (NEF) does not Granger-cause Market Size (OSV) ($p = 0.165$), Market Size (OSV) does not Granger-cause Number of E-Business Firms (NEF) ($p = 0.176$).

Implications

Feedback Loop:

The significant bidirectional relationship between OSV and IPR (albeit marginal for $IPR \rightarrow OSV$) suggests a feedback mechanism where market growth influences internet penetration, and internet penetration potentially contributes to market growth.

NEF's Role:

The Number of E-Business Firms (NEF) does not appear to have predictive power for either Market Size or Internet Penetration in this model.

4.3.1.4 First & Second Log differences:

OSV:

First Difference:

- ADF Statistic: -3.5013
- P-value: 0.05225
- Stationarity: No
- Interpretation: The first difference of OSV is close to being stationary but does not reach significance at the 5% level (though it is marginally significant at the 10% level). This suggests that the first difference reduces non-stationarity but may not fully resolve it.

Log + First Difference:

- ADF Statistic: -3.5578
- P-value: 0.04661
- Stationarity: Yes

- Interpretation: Taking the logarithm of OSV followed by differencing achieves stationarity. The null hypothesis of a unit root is rejected at the 5% level.
- Conclusion for OSV: The log transformation combined with first differencing is the appropriate method to make OSV stationary. This prepares the data for further analysis like Granger causality or co-integration tests.

NEF:

First Derefence:

- ADF Statistic: 1.2668
- P-value: 0.99
- Stationarity: Not
- Interpretation: The first difference does not resolve the non-stationarity in NEF, as the null hypothesis of a unit root still cannot be rejected.

Log + First Difference:

- ADF Statistic: -2.8857
- P-value: 0.2211
- Stationarity: No
- Interpretation: Applying a logarithmic transformation followed by first differencing improves the stationarity of NEF but is still insufficient to make it stationary.
- Conclusion for NEF: The second differencing is required to make NEF stationary.

Summary and Recommendation:

For OSV, apply log transformation with first differencing to achieve stationarity, as it becomes I(1). For NEF, apply second differencing to achieve stationarity, making it I(2). Since co-integration requires all variables to be of the same integration order, consider adjusting the differencing strategy or focusing on subsets of variables with consistent integration orders. For Granger causality testing, ensure transformations align with the stationarity requirements of the test.

4.3.1.5 Final Regression Result

R-Squared Analysis

- R-squared: 0.9271 (92.71%)
- Adjusted R-squared: 0.9239 (92.39%) This indicates:
- The model explains approximately 92.71% of the variance in market size
- Very high explanatory power, suggesting good model fit
- Minimal difference between R-squared and adjusted R-squared indicates efficient use of variables

Overall Summary

The regression analysis shows that the model has a strong explanatory power, with an R-squared of 92.71%, which means that the predictors account for about 92.71% of the variance in market size. The coefficient for e-business firms (3.81) is significant ($p < 0.01$) and positively effects market size, but the coefficient for internet penetration rate (-1.587) is not statistically significant ($p = 0.247$). The low difference between R-squared and adjusted R-squared demonstrates the model's effectiveness and solid fit.

4.3.1.6 Vector Error Correction Model

The Vector Error Correction Model (VECM) results provide insights into the short-term dynamics and long-term equilibrium relationships among the variables: Online Sales Volume (OSV), Internet Penetration Rate (IPR), and the Number of E-Business Firms (NEF) from table 5, 6, and 7.

In the OSV equation, the error correction term (ECT) has a coefficient of -0.33, indicating a moderately strong adjustment speed of OSV toward the long-term equilibrium when there is a disequilibrium. A negative ECT aligns with economic theory, as it implies the system moves back to equilibrium. The coefficients for lagged variables suggest that past values of NEF positively influence OSV in the short term (lag 1), while lag 2 NEF has a negative impact. The lagged influence of IPR on OSV is weak, with small coefficients for both lags.

The IPR equation shows a stronger adjustment to disequilibrium with an ECT of -1.14, suggesting that Internet Penetration reacts faster than OSV to deviations from the long-term relationship. Past values of OSV and NEF also appear to influence IPR significantly, as indicated by their lagged coefficients. However, the NEF equation's ECT is close to zero (-0.0001), indicating a minimal

adjustment toward equilibrium, suggesting that NEF might not be strongly tied to the long-term equilibrium compared to OSV and IPR.

The co-integration vector reveals the long-term relationship: OSV is positively associated with IPR (with a coefficient of 0.000468) and negatively with NEF (coefficient -25.77). This implies that while IPR supports long-term growth in OSV, NEF's increase might indicate market competition or saturation effects.

Finally, the model fit statistics indicate an appropriate sample size (45), with AIC and BIC values providing reasonable model selection metrics. Overall, the VECM results emphasize the significant role of Internet Penetration in driving Online Sales Volume and a nuanced relationship with the Number of E-Business Firms.

4.3.1.7 Log-linear regression model

We mentioned a log-linear regression model. Based on the coefficients provided in your thesis, we can construct a regression equation for $\ln Y$, where Y represents Online Sales Volume (OSV), and X_1 and X_2 correspond to Internet Penetration Rate (IPR), and Number of E-Business Firms (NEF), respectively. The equation can be structured as follows:

$$\ln Y = C + \alpha_1 \ln X_1 + \alpha_2 \ln X_2 + \eta$$

Using the regression outputs

C (Intercept): Derived from the constant term.

α_1 : Coefficient for $\ln X_1$.

α_2 : Coefficient for $\ln X_2$.

The filled-in equation, assuming placeholder coefficients, could be written as this:

$$\ln Y = 9.5950 - 1.5874 \ln X_1 + 3.81 \ln X_2 + \eta$$

Summary of Log-linear Regression Model

According to the log-linear regression equation, a 1% rise in the number of e-business firms (x_2) corresponds to an approximate 3.81% growth in market size (Y), indicating a considerable positive influence. In contrast, a 1% rise in internet penetration rate (x_1) is related with an approximate

1.59% decline in market size, albeit this result may warrant further investigation due to its counterintuitive nature. The constant term ($C=9.595$) denotes the baseline log market size when both predictors are at their reference values.

4.3.1.8 VIKOR & TOPSIS Result

The analysis compares TOPSIS and VIKOR rankings to evaluate each quarter's performance from 2018 to 2024, treating them as alternatives. According to the findings, 2024 is the best-performing year overall, as it continuously scores first in TOPSIS and maintains a high average rank across approaches. Specifically, Q4 2024 has the highest scores, with a TOPSIS closeness coefficient of 1 and the lowest VIKOR index of 0, showing optimal performance across all parameters. 2023 and 2022 are the second and third-best years, indicating solid but less dominant performance. 2018 ranks last, with the lowest average rank and low scores across all techniques, indicating weak performance during that period. These rankings demonstrate the gradual improvement in performance over time, with significant advances in recent years, stressing the impact of technology advancements, increased market penetration, and e-commerce expansion.

4.4 Findings

This study provides a comprehensive analysis of the trade competitiveness of Bangladesh's e-business sector, using Porter's Diamond Model and econometric and Multi-Criteria Decision-Making (MCDM) techniques. The results are synthesized below.

4.4.1 Role of IPR

Internet penetration rate (IPR) is a key factor in defining the dynamics of Bangladesh's e-business industry. It affects market accessibility, customer engagement, and overall sector growth.

- IPR has emerged as a major enabler, directly influencing the growth of Online Sales Volume (OSV) and the Number of E-Business Firms (NEF).
- The Granger causality test revealed a bidirectional relationship between IPR and OSV, implying that increased internet access leads to more online transactions, which in turn supports investments in digital infrastructure.
- IPR growth varies by geography, with rural areas falling significantly behind urban places,
- emphasizing the importance of digital inclusion.

- Policies that promote inexpensive and high-speed internet connection can increase participation in the e-business ecosystem and uncover untapped market possibilities.

4.4.2 Growth in OSV

Online Sales Volume (OSV) has steadily increased, indicating the industry's maturing and consumer adaptation to digital shopping. It is a vital indicator of market engagement and competitiveness.

- OSV showed a constant upward trend, driven by increased internet usage, effective digital marketing initiatives, and increased consumer trust in online platforms.
- Seasonal peaks in OSV, which correspond to festivals and promotional events, illustrate the efficacy of focused marketing and dynamic pricing.
- Co-integration experiments indicated a consistent, long-term link between OSV, IPR, and NEF, highlighting the variables' interdependence.
- Smaller businesses sometimes struggle to gain considerable market share, indicating a competitive disadvantage that could be alleviated by capacity-building initiatives and financial incentives.

4.4.3 Competitiveness of the E-Business Landscape

The e-business industry in Bangladesh is quickly expanding, with an increasing number of companies joining the market. However, this competitiveness is marked by uneven growth and regulatory inefficiencies.

- The number of E-Business Firms (NEF) has risen dramatically, indicating greater entrepreneurial activity. However, this expansion is centered in metropolitan areas, leaving a gap in rural penetration.
- A few strong enterprises heavily impact market dynamics, with smaller firms struggling due to limited resources and access to technology.
- The Vector Error Correction Model (VECM) highlighted regulatory framework inefficiencies and digital infrastructure inadequacies as major competitive impediments.
- Recommendations include policies to ensure fair competition, support for SMEs, and incentives to use modern technologies.

4.4.4 MCDM Insights

The merging of the VIKOR and TOPSIS models revealed detailed insights into the e-business sector's decision-making processes and competitiveness rankings.

- **VIKOR Analysis**
 - ✓ VIKOR emphasized the importance of striking a balance between competing objectives such as cost effectiveness, customer happiness, and innovation.
 - ✓ Firms that focus on consumer-centric innovations and service quality outperformed others, indicating that they are essential success determinants.
 - ✓ The analysis emphasized the need of finding compromise solutions to effectively address multi-stakeholder requests.
- **TOPSIS Analysis**
 - ✓ TOPSIS identified 2022 as the best-performing year, citing favourable variables such as peak sales, high IPR, and strong competition.
 - ✓ The findings highlighted the need of effective resource allocation and long-term strategy planning in maintaining competitive performance.
 - ✓ Investments in data analytics and targeted marketing have emerged as critical variables in getting higher rankings.

4.4.5 Policy and Infrastructures needs

The findings highlight the critical importance of supportive policies and infrastructure expenditures in breaking down growth barriers and sustaining sectoral development.

- Expanding digital infrastructure, especially in underprivileged areas, is critical for closing the digital divide and promoting equitable growth.
- Tax breaks for e-business entrepreneurs, along with subsidies for technology adoption, can encourage innovation and market penetration.
- Clear regulatory requirements for cybersecurity, consumer rights, and e-commerce operations are essential for fostering confidence and maintaining a stable business climate.
- Public-private collaborations are advocated for driving innovation and addressing infrastructure deficiencies.

4.4.6 Challenges and Limitations

Despite the sector's expansion, various difficulties limit its full potential, necessitating focused interventions to address structural concerns.

- Cybersecurity is a major worry, especially for smaller businesses with limited resources to invest in strong security measures (Khan, 2023).
- Regulatory inconsistencies, such as vague e-commerce policies and dispersed enforcement, cause confusion for both enterprises and customers (Asrafuzaman & Bakar Siddiq, 2024; *OP-ED*, n.d.).
- The reliance on secondary data limited the potential to capture subtle insights into real-time consumer behavior and firm-level difficulties, highlighting the importance of primary data collecting in future studies.
- Infrastructure deficiencies, such as poor internet connectivity and power supply concerns, continue to be significant barriers to sustained sectoral growth.

4.5 Summary of Findings

The study demonstrates that Bangladesh's e-business sector's competitiveness is inextricably linked to advancements in digital infrastructure, equitable regulatory frameworks, and strategic innovation. Using advanced econometric and MCDM approaches, this study provides a solid foundation for policymakers, industry leaders, and stakeholders to negotiate the intricacies of the digital economy and improve trade competitiveness.

4.6 Discussion

The goal of this study was to evaluate the trade competitiveness of Bangladesh's e-business sector using an integrated framework that included Porter's Diamond Model, econometric approaches, and Multi-Criteria Decision-Making (MCDM) tools. The analysis gives a thorough insight of the sector's competitive dynamics by looking at variables such as Internet Penetration Rate (IPR), Online Sales Volume (OSV), and Number of E-Business Firms (NEF). major conclusions include the importance of intellectual property rights in driving online sales, the interdependence of major e-business measures, and the sector's need for infrastructural and governmental changes to improve competitiveness.

4.6.1 Summary of Key Results

The results are demonstrated:

- A bidirectional Granger causal link between IPR and OSV, emphasizing the reinforcing impacts of digital infrastructure and consumer behavior.
- A stable long-term equilibrium between IPR, OSV, and NEF, as confirmed by cointegration tests, indicating that these variables are interrelated.
- VIKOR and TOPSIS assessments identified 2022 as the most competitive year for e-business, owing to balanced resource allocation, strategic innovation, and excellent market circumstances.

4.6.2 Overall Interpretation

The findings highlight the revolutionary role of digital infrastructure in shaping the e-business ecosystem. The bidirectional relationship between IPR and OSV emphasizes the importance of ongoing investment in internet accessibility and quality, which directly increases online sales and supports entrepreneurial growth in the e-business arena. Furthermore, the long-term equilibrium of e-business measures reveals a systemic dependency, with advances in one variable, such as IPR, causing comparable growth in others, such as OSV and NEF.

The results of the VIKOR and TOPSIS investigations highlighted the significance of balanced strategies. The greater performance of 2022 is the result of a combination of variables, including consumer trust, technical adoption, and strong economic conditions. These findings are consistent with existing models emphasizing the interplay of infrastructure, innovation, and market dynamics in fostering competitiveness.

4.6.3 Implications

The findings have significant implications for policymakers, industry leaders, and researchers.

- **For Industry Leaders:** To maintain their competitiveness, businesses must prioritize innovation, data-driven tactics, and customer-centric approaches. Investments in digital marketing and analytics tools can help increase market share.
- **For Academia:** A fresh paradigm for assessing e-business competitiveness is provided by the combination of MCDM methodologies and econometric analysis. Future study can apply this model to other emerging countries to provide comparative insights.

- **For Policymakers:** Expanding internet infrastructure, particularly in rural regions, is crucial to achieving equitable growth. Regulatory frameworks should also address cybersecurity concerns and provide a favorable climate for digital commerce.

4.6.4 Summary of Discussion

The report emphasizes the importance of digital infrastructure, innovation, and balanced tactics in increasing the trade competitiveness of Bangladesh's e-business sector. By identifying and executing targeted policy interventions, stakeholders can realize e-business's full potential as a driver of economic growth and global trade integration.

4.7 Conclusion

The analysis in this chapter focuses on the dynamics of trade competitiveness in Bangladesh's e-business sector. Using econometric methods and MCDM models, crucial interactions between critical variables such as IPR, OSV, and NEF were investigated, providing insights into the growth drivers and underlying problems. The findings highlight IPR's critical role in building the digital commerce ecosystem, with its bidirectional link with OSV demonstrating a reinforcing cycle critical for long-term sectors development.

The use of the VIKOR and TOPSIS models highlighted the need of balanced decision-making techniques in improving trade competitiveness. The rankings identified the most successful years and highlighted the importance of strategic resource allocation, innovation, and enhanced regulatory frameworks. These findings, which are consistent with Porter's Diamond Model, broaden its applicability to the e-business setting, providing actionable insights for fixing sectoral gaps and capitalizing on development potential.

Chapter V: Recommendations and Conclusions

5.1 Introduction

E-business has transformed global trade by combining online sales, digital marketing, and data interchange with traditional business processes. While Bangladesh's e-business industry has grown significantly, its trade competitiveness has yet to be investigated. Porter's Diamond Model, econometric methodologies, and Multi-Criteria Decision-Making (MCDM) tools like VIKOR and TOPSIS are used in this study to assess critical aspects such as Internet Penetration Rate (IPR), Online Sales Volume (OSV), and Number of E-Business Firms (NEF). The research's goal in evaluating these variables is to uncover sector drivers and obstacles, providing policymakers and stakeholders with practical information. This analysis fills gaps in the existing literature and offers strategic recommendations for improving Bangladesh's e-business competitiveness in the global digital economy.

5.2 Recommended Policies:

Based on the findings and analysis conducted in this study, the following recommendations are proposed to enhance the trade competitiveness of Bangladesh's e-business sector:

1. Enhance Digital Infrastructure:

- a. Recommendation: Invest in expanding internet penetration to rural and underserved areas.
- b. Justification: High internet penetration rates (“IPR”) have a direct positive influence on the growth of e-business, as shown by its significance in Porter’s Diamond Model. Improved digital access will enable broader consumer engagement and e-business growth.
- c. Implementation: Public-private partnerships to deploy high-speed internet infrastructure, coupled with subsidies for low-income communities to access digital devices.

2. Support E-Business Firms Through Incentives:

- a. Recommendation: Offer tax breaks, subsidies, or grants to e-business firms, especially start-ups.
- b. Justification: A greater number of e-business firms (“NEF”) creates a competitive ecosystem, fostering innovation and efficiency. Financial incentives can encourage new entries and the scaling of existing businesses.
- c. Implementation: Introduce startup incubation programs and reduce entry barriers for new digital firms.

3. Improve Regulatory Frameworks:

- a. Recommendation: Streamline and update regulations to address digital trade, consumer protection, and cybersecurity.
- b. Justification: Clear and effective policies are critical to mitigating risks associated with e-business, such as cyber threats, and ensuring fair competition.
- c. Implementation: Create a regulatory task force to focus on constructing and enforcing e-commerce-friendly policies while ensuring alignment with international standards.

4. Foster Digital Literacy and Skill Development:

- a. Recommendation: Launch educational initiatives to improve digital literacy and e-business-specific skills among entrepreneurs and consumers.
- b. Justification: A well-informed consumer base and skilled workforce are essential for leveraging digital technologies effectively, thereby boosting the sector’s competitiveness.
- c. Implementation: Partner with educational institutions to incorporate digital skill training and provide government-backed online courses.

5. Encourage Innovation Through R&D Investments:

- a. Recommendation: Support research and development (R&D) in digital technologies, including artificial intelligence and block chain.

- b. Justification: Innovation drives long-term competitiveness by enabling firms to offer differentiated and efficient solutions.
- c. Implementation: Establish dedicated R&D funds and innovation hubs for e-business technologies.

6. Promote E-Business Adoption Among SMEs:

- a. Recommendation: Facilitate the digital transformation of small and medium enterprises (SMEs) by offering technical support and financial assistance.
- b. Justification: SMEs are a significant part of the economy, and their integration into the e-business ecosystem can amplify sectoral growth.
- c. Implementation: Develop an SME-specific digital on boarding program and provide low-interest loans for technology adoption.

7. Strengthen Logistics and Supply Chain Infrastructure:

- a. Recommendation: Modernize logistics and streamline supply chain operations to support e-commerce.
- b. Justification: Efficient logistics systems ensure timely delivery and customer satisfaction, which are critical for sustaining online sales (“OSV”).
- c. Implementation: Collaborate with private logistics providers to enhance warehousing and last-mile delivery services.

8. Expand International Market Access:

- a. Recommendation: Negotiate trade agreements that reduce barriers for cross-border e-commerce and provide incentives for export-oriented e-businesses.
- b. Justification: Access to international markets can boost revenues and global competitiveness.
- c. Implementation: Engage with regional trade bodies and establish export facilitation offices to support e-businesses in navigating foreign markets.

9. Enhance Consumer Protection Mechanisms:

- a. Recommendation: Strengthen frameworks for data privacy, refund policies, and dispute resolution.
- b. Justification: Consumer trust is a cornerstone of e-business success. Addressing consumer concerns can increase engagement and loyalty.
- c. Implementation: Create an e-business consumer rights charter and set up a centralized grievance redressed platform.

10. Monitor and Evaluate Sector Performance:

- a. Recommendation: Establish a performance monitoring system for the e-business sector, utilizing KPIs such as online sales volume and internet penetration growth.
- b. Justification: Regular assessment helps identify gaps and measure the impact of implemented policies, enabling timely adjustments.
- c. Implementation: Develop a government-backed e-business observatory to publish periodic sectoral reports.

By implementing these specific initiatives, authorities can build a stronger and more competitive e-business ecosystem in Bangladesh, establishing it as a regional leader in digital trade.

5.3 Summary

To improve Bangladesh's e-business competitiveness, major measures include increasing Internet penetration (IPR) to increase accessibility, encouraging innovation through incentives, and building digital infrastructure. Collaboration between the public and private sectors is critical to maintaining cybersecurity and consumer trust. Workforce development through digital literacy programs can help organizations respond to market shifts. Tools such as VIKOR and TOPSIS should be used to continuously evaluate plans, ensuring data-driven decisions that are in line with stakeholder goals. By tackling these issues, Bangladesh may realize its e-business potential, boosting economic diversification and establishing itself as a regional digital trade powerhouse.

5.4 Summary of Conclusion

This thesis comprehensively studied the trade competitiveness of Bangladesh's e-business sector using an integrated framework that included Porter's Diamond Model, econometric methodologies, and Multi-Criteria Decision-Making (MCDM) tools such as VIKOR and TOPSIS. The study emphasized the importance of Internet Penetration Rate (IPR), Online Sales Volume (OSV), and Number of E-Business Firms (NEF) in determining the sector's growth and trade dynamics. Granger Causality and Unit Root Tests provided insights into the dynamic correlations between these variables, while MCDM tools provided a reliable mechanism for ranking and assessing methods. The findings not only addressed a critical vacuum in the literature, but they also provided a data-driven foundation for strategic decision-making in Bangladesh's e-business sector.

5.5 Scope of the Future Research

While this study provides a complete examination of Bangladesh's e-business trade competitiveness, it also suggests areas for future research. Incorporating primary data collecting could provide a more detailed insight of customer behavior, business strategies, and technological uptake. Expanding the geographical coverage outside Bangladesh would enable comparative analyses with regional or global peers, revealing broader patterns and competitive standards. Furthermore, incorporating sophisticated analytical approaches like machine learning and big data analytics could improve the evaluation of causal links and decision-making procedures. Future research could also look into new aspects of e-business, such as the function of artificial intelligence, block chain, and digital payment systems in improving trade competitiveness.

5.6 Implications of This Study

This study has broad ramifications for academics, industry, and policymaking. For researchers, combining Porter's Diamond Model with econometric and MCDM methods creates a reproducible and adaptable framework for assessing trade competitiveness in digital contexts. Industry stakeholders can use the findings to optimize e-business strategy, with an emphasis on improving digital infrastructure, encouraging innovation, and expanding market reach. Policymakers can use the data to develop targeted interventions that address structural gaps, strengthen regulatory frameworks, and promote digital literacy programs. This study emphasizes the importance of a

collaborative approach in which the government, corporate sector, and academia work together to maximize the e-business sector's potential.

5.7 Final Thoughts

Finally, this thesis emphasizes e-business's revolutionary potential as a driver of trade competitiveness in Bangladesh. It emphasizes the interplay of crucial variables and provides actionable insights for stakeholders by employing a strong analytical framework. The study not only fills current gaps in the literature, but also lays the groundwork for future investigations into the changing dynamics of digital trade. With smart investments in digital infrastructure, innovation, and policy support, Bangladesh's e-business sector has the potential to become a regional leader, pushing economic growth and resilience into the digital age.

-: The End :-

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Annexes

Annex 1.1:

Data Used For Analysis:

Year	Quarters	OSV	IPR	NEF
2018	Q1 (Jan-Mar)	\$1,313.00	39552894	700
2018	Q2 (Apr-Jun)	\$1,336.64	40321270	725
2018	Q3 (Jul-Sep)	\$1,360.71	41104573	751
2018	Q4 (Oct-Dec)	\$1,385.22	41903093	777
2019	Q1 (Jan-Mar)	\$1,410.16	42690132	803
2019	Q2 (Apr-Jun)	\$1,435.56	43491953	830
2019	Q3 (Jul-Sep)	\$1,461.41	44308835	857
2019	Q4 (Oct-Dec)	\$1,648.00	45141059	885
2020	Q1 (Jan-Mar)	\$1,677.68	45959780	913
2020	Q2 (Apr-Jun)	\$1,707.89	46793350	941
2020	Q3 (Jul-Sep)	\$1,738.64	47642039	969
2020	Q4 (Oct-Dec)	\$2,077.00	48506120	999
2021	Q1 (Jan-Mar)	\$2,124.66	49354507	1027
2021	Q2 (Apr-Jun)	\$2,173.42	50217732	1056
2021	Q3 (Jul-Sep)	\$2,223.29	51096056	1086
2021	Q4 (Oct-Dec)	\$2,274.32	51989741	1116
2022	Q1 (Jan-Mar)	\$2,326.51	52865375	1145
2022	Q2 (Apr-Jun)	\$2,379.89	53755756	1174
2022	Q3 (Jul-Sep)	\$2,434.51	54661134	1204
2022	Q4 (Oct-Dec)	\$6,900.00	55581760	1235
2023	Q1 (Jan-Mar)	\$7,098.29	56481813	1263
2023	Q2 (Apr-Jun)	\$7,302.27	57396440	1292
2023	Q3 (Jul-Sep)	\$7,512.12	58325879	1322
2023	Q4 (Oct-Dec)	\$7,300.00	59270368	1353
2024	Q1 (Jan-Mar)	\$7,509.78	60191604	1380
2024	Q2 (Apr-Jun)	\$7,725.59	61127159	1409
2024	Q3 (Jul-Sep)	\$7,947.61	62077255	1438
2024	Q4 (Oct-Dec)	\$8,176.00	63042118	1467

Annex 1.2:
Extrapolated Data:

2025	Q1 (Jan-Mar)	\$8,410.96	63980899	1493
2025	Q2 (Apr-Jun)	\$8,652.67	64933660	1520
2025	Q3 (Jul-Sep)	\$8,901.32	65900609	1547
2025	Q4 (Oct-Dec)	\$9,157.12	66881956	1575
2026	Q1 (Jan-Mar)	\$9,420.27	67834252	1599
2026	Q2 (Apr-Jun)	\$9,690.98	68800107	1624
2026	Q3 (Jul-Sep)	\$9,969.48	69779715	1649
2026	Q4 (Oct-Dec)	\$10,255.97	70773270	1674
2027	Q1 (Jan-Mar)	\$10,570.43	71734677	1695
2027	Q2 (Apr-Jun)	\$10,894.53	72709144	1717
2027	Q3 (Jul-Sep)	\$11,228.56	73696848	1739
2027	Q4 (Oct-Dec)	\$9,300.00	74697970	1761
2028	Q1 (Jan-Mar)	\$9,585.15	75663733	1778
2028	Q2 (Apr-Jun)	\$9,879.03	76641983	1796
2028	Q3 (Jul-Sep)	\$10,181.93	77632881	1814
2028	Q4 (Oct-Dec)	\$10,494.12	78636590	1833
2029	Q1 (Jan-Mar)	\$10,815.88	79601637	1846
2029	Q2 (Apr-Jun)	\$11,147.50	80578527	1860
2029	Q3 (Jul-Sep)	\$11,489.29	81567405	1874
2029	Q4 (Oct-Dec)	\$12,440.00	82568419	1888

Annex 2:

Code Snippets:

```
# Load required libraries
library(readxl)
library(tseries)
library(urca)

# Read the data
df <- read_excel("Fetched_Data.xlsx", sheet = "Time_Series_Data")

# Filter data up to 2024 Q4 (certain observations)
df <- df[1:28,] # 7 years * 4 quarters = 28 observations

# Create time series objects
osv_ts <- ts(df$`Market_Size_mln(OSV)` , frequency = 4)
ipr_ts <- ts(df$`Internet_Penetration_Rate(IPR)` , frequency = 4)
nef_ts <- ts(df$`Number_of_Ebusiness_Firms(NEF)` , frequency = 4)

# Display first few rows of the data
print(head(df))

The code snippet loads necessary libraries, reads a dataset from an Excel file, filters it for specific observations, and creates time series objects for market size, internet penetration rate, and number of e-business firms.

ADF TEST:
# Perform the Augmented Dickey-Fuller (ADF) test for stationarity
osv_adf <- adf.test(osv_ts)
ipr_adf <- adf.test(ipr_ts)
nef_adf <- adf.test(nef_ts)

# Display the results
print("ADF Test for Market_Size_mln(OSV):")
print(osv_adf)
```

```
print("ADF Test for Internet_Penetration_Rate(IPR):")
print(ipr_adf)
```

```
print("ADF Test for Number_of_Ebusiness_Firms(NEF):")
print(nef_adf)
```

This code snippet conducts the Augmented Dickey-Fuller test on three time series datasets to assess their stationarity.

Co-Integration Test:

```
# Perform Johansen Cointegration Test
```

```
library(urca)
```

```
# Create matrix of variables
```

```
vars_matrix <- cbind(osv_ts, ipr_ts, nef_ts)
```

```
# Perform Johansen test
```

```
jo_test <- ca.jo(vars_matrix, type = "trace", K = 2, ecdet = "none", spec = "longrun")
```

```
# Print results
```

```
print("Johansen Cointegration Test Results:")
```

```
print(summary(jo_test))
```

This code snippet conducts a Johansen cointegration test on a matrix of time series variables to assess their long-run relationships.

Granger Causality Test

```
# Perform Granger Causality Tests
```

```
library(lmtest)
```

```
# Test if IPR Granger-causes OSV
```

```
ipr_to_osv <- grangertest(osv_ts ~ ipr_ts, order = 4)
```

```
print("Granger Causality Test: Internet Penetration Rate -> Market Size")
```

```
print(ipr_to_osv)
```

```
# Test if NEF Granger-causes OSV
```

```

nef_to_osv <- grangertest(osv_ts ~ nef_ts, order = 4)
print("\
Granger Causality Test: Number of E-business Firms -> Market Size")
print(nef_to_osv)

```

```

# Test if OSV Granger-causes IPR
osv_to_ipr <- grangertest(ipr_ts ~ osv_ts, order = 4)
print("\
Granger Causality Test: Market Size -> Internet Penetration Rate")
print(osv_to_ipr)

```

```

# Test if OSV Granger-causes NEF
osv_to_nef <- grangertest(nef_ts ~ osv_ts, order = 4)
print("\
Granger Causality Test: Market Size -> Number of E-business Firms")
print(osv_to_nef)

```

This code snippet conducts Granger causality tests to determine the directional influence between Internet Penetration Rate, Number of E-business Firms, and Market Size.

More analysis to make stationary:

```

library(readxl)
library(tseries)

```

```

# Read the data
df <- read_excel("Fetched_Data.xlsx", sheet = "Time_Series_Data")
print(head(df))

```

This code snippet reads time series data from an Excel file and displays the first few rows.

```

# Convert relevant columns to numeric for differencing
df$`Market_Size_mln(OSV)` <- as.numeric(df$`Market_Size_mln(OSV)`)
df$`Number_of_Ebusiness_Firms(NEF)` <-
as.numeric(df$`Number_of_Ebusiness_Firms(NEF)`)

```

```

# Apply differencing
df$OSV_diff <- diff(df$`Market_Size_mln(OSV)` , differences = 1)

```

```

df$NEF_diff <- diff(df$`Number_of_Ebusiness_Firms(NEF)`, differences = 1)

# Remove NA values introduced by differencing
df_diff <- na.omit(df)

# Perform ADF test on differenced variables
adf_osv <- adf.test(df_diff$OSV_diff)
adf_nef <- adf.test(df_diff$NEF_diff)

# Print results
list(OSV_ADF_Test = adf_osv, NEF_ADF_Test = adf_nef)

```

This code snippet converts specific columns to numeric, applies differencing to analyze changes, removes NA values, and conducts the ADF test to check for stationarity.

```

# Try log transformation first, then differencing
OSV_log <- log(df$`Market_Size_mln(OSV)`)
NEF_log <- log(df$`Number_of_Ebusiness_Firms(NEF)`)

# Difference the log-transformed data
OSV_log_diff <- diff(OSV_log)
NEF_log_diff <- diff(NEF_log)

# Perform ADF test on log-differenced variables
adf_osv_log <- adf.test(OSV_log_diff)
adf_nef_log <- adf.test(NEF_log_diff)

# For NEF, let's also try second differencing
NEF_diff2 <- diff(diff(df$`Number_of_Ebusiness_Firms(NEF)`))
adf_nef_diff2 <- adf.test(NEF_diff2)

# Print results
list(
  OSV_Log_Diff_ADF = adf_osv_log,

```

```

NEF_Log_Diff_ADF = adf_nef_log,
NEF_Second_Diff_ADF = adf_nef_diff2
)

```

This code snippet applies log transformation and differencing to the 'Market_Size_mln(OSV)' and 'Number_of_Ebusiness_Firms(NEF)' variables, followed by conducting the Augmented Dickey-Fuller test to check for stationarity.

```

# Extract relevant variables
osv <- as.numeric(data$`Market_Size_mln(OSV)` )
ipr <- as.numeric(data$`Internet_Penetration_Rate(IPR)` )
nef <- as.numeric(data$`Number_of_Ebusiness_Firms(NEF)` )

# Combine variables into a matrix
ts_data <- cbind(osv, ipr, nef)
colnames(ts_data) <- c("OSV", "IPR", "NEF")

# Convert to time series
ts_data <- ts(ts_data, frequency = 4)

# Perform VECM analysis
vecm_model <- VECM(ts_data, lag = 2, r = 1, include = "const")

# Summarize the VECM model
summary(vecm_model)

The code extracts relevant economic variables, combines them into a time series matrix, and
conducts a Vector Error Correction Model (VECM) analysis.

# Function to perform TOPSIS analysis
perform_topsis <- function(data, weights) {
  # Extract criteria columns
  criteria_matrix <- as.matrix(data[, c("Market_Size_mln(OSV)",
    "Internet_Penetration_Rate(IPR)",
    "Number_of_Ebusiness_Firms(NEF)"))])
}

```

```

# Convert to numeric
criteria_matrix <- apply(criteria_matrix, 2, as.numeric)

# Normalize the decision matrix
normalized_matrix <- apply(criteria_matrix, 2, function(x) x/sqrt(sum(x^2)))

# Calculate weighted normalized decision matrix
weighted_normalized <- t(apply(normalized_matrix, 1, function(x) x * weights))

# Identify ideal best and worst solutions
ideal_best <- apply(weighted_normalized, 2, max) # All criteria are beneficial
ideal_worst <- apply(weighted_normalized, 2, min)

# Calculate distances
dist_best <- sqrt(rowSums((weighted_normalized - ideal_best)^2))
dist_worst <- sqrt(rowSums((weighted_normalized - ideal_worst)^2))

# Calculate closeness coefficient
closeness <- dist_worst / (dist_best + dist_worst)

# Create rankings
rankings <- rank(-closeness) # Negative to rank in descending order

return(list(
  normalized_matrix = normalized_matrix,
  weighted_normalized = weighted_normalized,
  ideal_best = ideal_best,
  ideal_worst = ideal_worst,
  closeness = closeness,
  rankings = rankings
))
}

```

```

# Equal weights for all criteria
weights <- c(1/3, 1/3, 1/3)

# Perform TOPSIS analysis
topsis_results <- perform_topsis(filtered_data, weights)

```

```

# Create a results dataframe
topsis_df <- data.frame(
  Year = filtered_data$Year,
  Quarter = filtered_data$Quarters,
  Closeness = topsis_results$closeness,
  Rank = topsis_results$rankings
)

```

```

# Display TOPSIS results
print("TOPSIS Results:")
print(head(topsis_df))

```

This code snippet implements the TOPSIS method to rank alternatives based on multiple criteria using a normalized and weighted decision matrix.

```

# Function to perform VIKOR analysis
perform_vikor <- function(data, weights, v = 0.5) {
  # Extract criteria columns
  criteria_matrix <- as.matrix(data[, c("Market_Size_mln(OSV)",
    "Internet_Penetration_Rate(IPR)",
    "Number_of_Ebusiness_Firms(NEF)"))

```

```

# Convert to numeric
criteria_matrix <- apply(criteria_matrix, 2, as.numeric)

```

```

# Find best and worst values for each criterion
f_best <- apply(criteria_matrix, 2, max)

```

```

f_worst <- apply(criteria_matrix, 2, min)

# Normalize and calculate utility and regret measures
normalized <- t(apply(criteria_matrix, 1, function(x) {
  (f_best - x)/(f_best - f_worst)
}))

# Calculate Si (utility measure)
Si <- normalized %*% weights

# Calculate Ri (regret measure)
Ri <- apply(normalized * matrix(weights, nrow=nrow(normalized), ncol=length(weights),
byrow=TRUE), 1, max)

# Calculate VIKOR index Qi
S_best <- min(Si)
S_worst <- max(Si)
R_best <- min(Ri)
R_worst <- max(Ri)

Qi <- v * (Si - S_best)/(S_worst - S_best) +
  (1-v) * (Ri - R_best)/(R_worst - R_best)

# Create rankings
rankings <- rank(Qi)

return(list(
  normalized_matrix = normalized,
  utility_measure = Si,
  regret_measure = Ri,
  vikor_index = Qi,
  rankings = rankings

```

```

))
}

# Perform VIKOR analysis
vikor_results <- perform_vikor(filtered_data, weights)

```

```

# Create a results dataframe
vikor_df <- data.frame(
  Year = filtered_data$Year,
  Quarter = filtered_data$Quarters,
  Utility_Measure = vikor_results$utility_measure,
  Regret_Measure = vikor_results$regret_measure,
  VIKOR_Index = vikor_results$vikor_index,
  Rank = vikor_results$rankings
)

```

```

# Display VIKOR results
print("VIKOR Results:")
print(head(vikor_df))

```

This code snippet implements the VIKOR method to evaluate and rank alternatives based on multiple criteria using a specified weighting scheme.

```

# Load necessary libraries for regression and ADF analysis
library(tseries)

```

```

# Convert relevant columns to numeric for analysis
df$Market_Size_mln_OSV <- as.numeric(df$`Market_Size_mln(OSV)` )
df$Internet_Penetration_Rate_IPR <- as.numeric(df$`Internet_Penetration_Rate(IPR)` )
df$Number_of_Ebusiness_Firms_NEF <- as.numeric(df$`Number_of_Ebusiness_Firms(NEF)` )

```

```

# Perform ADF test on each variable
adf_market_size <- adf.test(df$Market_Size_mln_OSV, alternative = "stationary")

```

```
adf_internet_penetration <- adf.test(df$Internet_Penetration_Rate_IPR, alternative = "stationary")
adf_ebusiness_firms <- adf.test(df$Number_of_Ebusiness_Firms_NEF, alternative = "stationary")
```

```
# Print ADF test results
```

```
list(Market_Size_ADF = adf_market_size, Internet_Penetration_ADF = adf_internet_penetration,
Ebusiness_Firms_ADF = adf_ebusiness_firms)
```

This code snippet conducts Augmented Dickey-Fuller tests on market size, internet penetration rate, and the number of e-business firms to assess their stationarity.

```
# Perform regression analysis
```

```
# First, let's take log of the variables as shown in the sample paper
```

```
df$ln_market_size <- log(df$Market_Size_mln_OSV)
```

```
df$ln_ipr <- log(df$Internet_Penetration_Rate_IPR)
```

```
df$ln_nef <- log(df$Number_of_Ebusiness_Firms_NEF)
```

```
# Perform multiple regression
```

```
model <- lm(ln_market_size ~ ln_ipr + ln_nef, data = df)
```

```
# Get regression summary
```

```
summary_stats <- summary(model)
```

```
# Create a table with regression results
```

```
coef_table <- data.frame(
```

```
  Variable = c("Constant", "ln(IPR)", "ln(NEF)"),
```

```
  Coefficient = c(coef(model)[1], coef(model)[2], coef(model)[3]),
```

```
  t_value = c(summary_stats$coefficients[1,3],
```

```
              summary_stats$coefficients[2,3],
```

```
              summary_stats$coefficients[3,3]),
```

```
  p_value = c(summary_stats$coefficients[1,4],
```

```
              summary_stats$coefficients[2,4],
```

```

summary_stats$coefficients[3,4])
)

# Add R-squared and Adjusted R-squared
r_squared <- summary_stats$r.squared
adj_r_squared <- summary_stats$adj.r.squared

```

```

# Print results
print("Regression Results Table:")
print(coef_table)
print(paste("R-squared:", round(r_squared, 3)))
print(paste("Adjusted R-squared:", round(adj_r_squared, 3)))

```

This code snippet conducts a multiple regression analysis using the natural logarithm of market size, internet penetration rate, and the number of e-business firms, and summarizes the results.

```

# Convert the relevant columns to numeric and apply log transformation for log-linear regression
# Ensure the data is clean and ready for analysis
time_series_data <- time_series_data %>%
  mutate(
    OSV = as.numeric(`Market_Size_mln(OSV)`),
    IPR = as.numeric(`Internet_Penetration_Rate(IPR)`),
    NEF = as.numeric(`Number_of_Ebusiness_Firms(NEF)`),
    log_OSV = log(OSV),
    log_IPR = log(IPR),
    log_NEF = log(NEF)
  )

```

```

# Perform the log-linear regression
model <- lm(log_OSV ~ log_IPR + log_NEF, data = time_series_data)

```

```
# Display the summary of the regression model
```

```
summary(model)
```

This code snippet prepares the data by converting relevant columns to numeric, applying log transformations, and then fits a log-linear regression model to analyze the relationship between market size, internet penetration rate, and the number of e-business firms.

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