2024 APRIL

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AMERICAN ECONOMIC ASSOCIATION

ISSN 2303-5005
EISSN 2303-5013

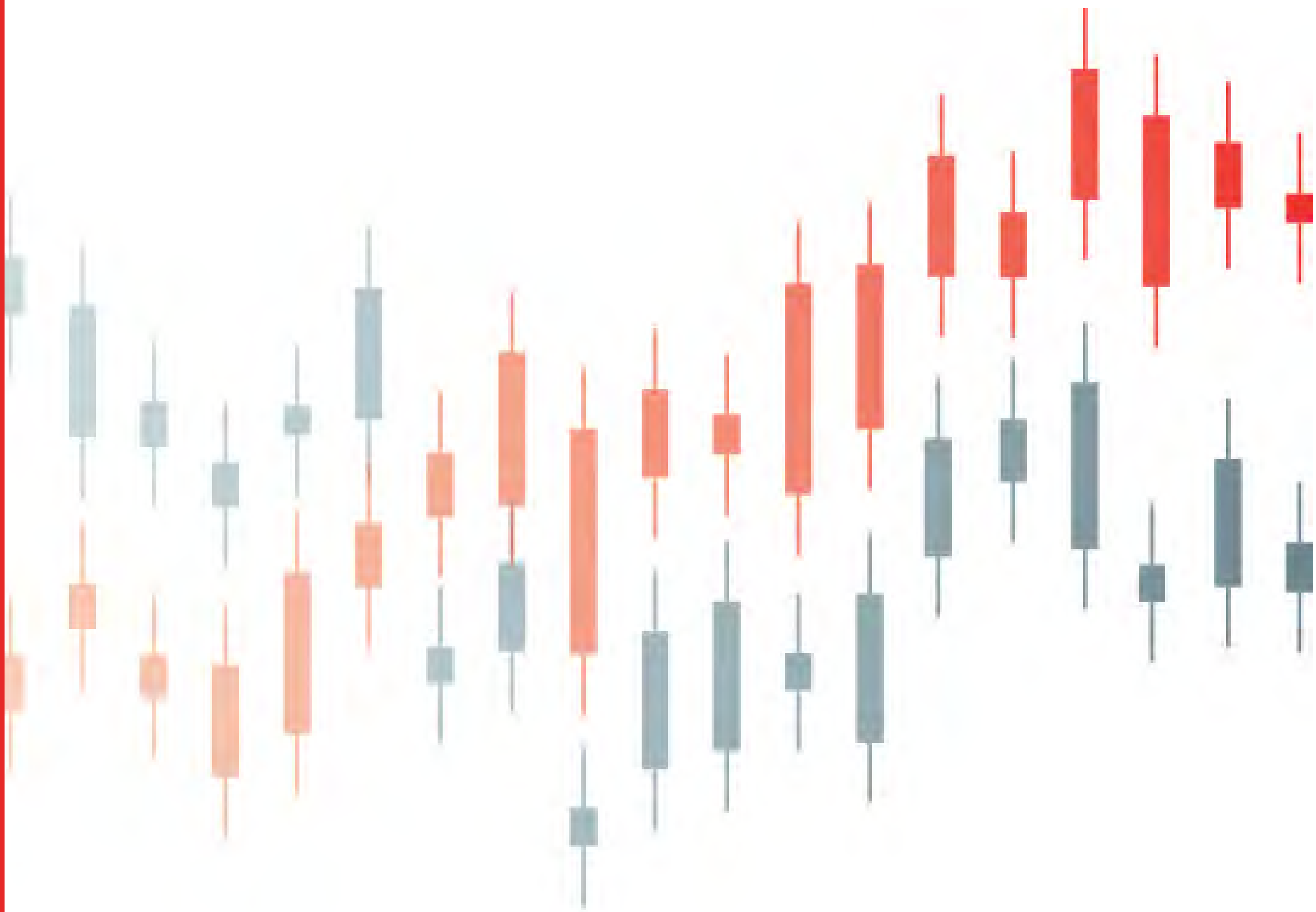
Volume 12, NO. 1

ECONOMICS

Innovative and Economics Research Journal

https://www.scopus.com/sourceid/21101122725
www.economicsrs.com

Volume 12, No. 1, April, 2024



ECONOMICS Innovative and Economics Research Journal

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Innovative and Economics Research Journal

PUBLISHED BY: Oikos Institute – Research Center Bijeljina" Bijeljina
FOR THE PUBLISHER: PhD Zoran Mastilo, Director

PAPERS PUBLISHED IN "ECONOMICS" JOURNAL ARE ABSTRACTED AND INDEXED BY:
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ID: 44035724600004

KATALOGIZATION:
Printed issue: ISSN 2303-5005
Online issue: EISSN 2303-5013
Desicion of the Ministry of Education and Culture of the Republic of Srpska No.: 07.061-053-52-12/13, od 10.12.2013, The Journal "Economics" entered in the Register of Public Media as item No. 645

Scientific Journal

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ECONOMICS
Innovative and Economics Research Journal
Volume 12, No. 1, 2024
www.economicsrs.com

APPLICATION OF FUZZY AHP IN PRIORITY BASED SELECTION OF FINANCIAL INDICES: A PERSPECTIVE FOR INVESTORS

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Received 13.02.2024. | Sent to review 23.02.2024. | Accepted 12.04.2024.

Original article

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JEL Classification: C44, E44, M21, G17

Doi: 10.2478/eoik-2024-0007

UDK: 336.763:338.124.4(100)

ABSTRACT

By providing important indicators, financial indices help investors make educated judgements regarding their assets, much like vital sign monitors for the financial markets. The best way for investors to keep up with the market and make strategic adjustments is to keep an eye on these indexes. Researching the most important financial indexes for making educated investing decisions is, thus, quite relevant. Finding the most essential financial indices from an investing standpoint and assigning a weight to each of those indexes are the main goals of this research. A weighted score is derived by combining four financial indices in a Multi-Criteria Decision-Making (MCDM) technique. These objectives are then pursued. Triangular Fuzzy Numbers (TFNs) and the Fuzzy Analytic Hierarchy Process (F-AHP) are used to determine the weights of criteria in this technique. Using these methods together, the research hopes to provide a thorough analysis of the role that different financial indexes have in informing investment choices. This study emphasizes the paramount importance of considering the Price Earning to Growth (PEG) ratio when making investment decisions, followed by the Debt Equity Ratio. Price to Book Value and Dividend Yield, while relevant, carry comparatively less weightage in the overall assessment. Investors are advised to use these insights as a guideline in their financial analysis and decision-making processes.

Keywords: *Financial Indices, Priority Selection, Multi-Criteria Decision-Making (MCDM), Triangular Fuzzy Number (TFN), Fuzzy Analytic Hierarchy Process (F-AHP)*

1. INTRODUCTION

The stock market which is known to us as the share market is a platform where a person individually and any organization purchase and sell ownership shares of publicly traded companies. These shares represent a claim on the assets and earnings of the company. The market serves as a means for companies to raise capital by issuing shares, and for investors to potentially earn profits through price appreciation or dividends. It is essential to the global economy since it makes financial flows easier and allows businesses to develop and flourish. There are two major parts of buying stocks are trading and Investment. Buying and selling financial products, such as stocks, bonds, commodities, or currencies, with the intention of turning a profit is referred to as trading. Traders typically operate in relatively short time frames, sometimes within seconds, minutes, hours, or days. To make well-informed judgments, they employ a variety of techniques, such as sentiment analysis, technical analysis, and fundamental analysis. Investment involves allocating money or resources into an asset or venture with the expectation of generating a return over an extended period. Unlike trading, investors typically have a longer-term perspective and are willing to withstand market fluctuations. Typical investment vehicles include of mutual funds, equities, bonds, and real estate. The goal of investing is to grow wealth over time through appreciation, dividends, or interest.

1. 1. STRUCTURE OF STOCK MARKETS IN INDIA

The two main stock exchanges in India are the Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE). The key indices include the BSE Sensex and the NSE Nifty. India's stock market was one of the largest in the world by market capitalization, with companies spanning various sectors. Foreign Institutional Investors (FIIs) wield considerable influence within the Indian stock market, and their financial contributions can exert a substantial influence on market fluctuations. Some Investment Instruments are:

- Equities: Equities or stocks symbolize ownership stakes in companies and are bought and sold on stock markets. They are a popular investment choice for many.
- Bonds: India has a well-developed bond market, with various types of bonds available, including government bonds, corporate bonds, and municipal bonds.
- Mutual Funds: Mutual funds combine funds from numerous investors to allocate them into a diversified array of stocks, bonds, or various securities.
- Real Estate: Real estate is a popular investment avenue in India, with residential and commercial properties being the primary sectors.
- Gold: India has a strong affinity for gold, and it is a common form of investment. It can be purchased in various forms, including jewelry, coins, and bars.

Government Policies and Regulations:

- SEBI (Securities and Exchange Board of India):SEBI serves as the regulatory body responsible for supervising the securities market in India. It regulates stock exchanges, brokers, and various market participants.
- RBI (Reserve Bank of India): RBI regulates the banking sector and formulates monetary policy, which indirectly affects investment decisions.

1. 2. PRESENT TRADING & INVESTMENT SCENARIO IN INDIA

Recent Trends and Developments:

- Digitalization and Fintech: India has seen a surge in digital trading platforms and fintech companies, making it easier for individuals to invest in various financial instruments.
- Retail Participation: The Indian stock market has witnessed increased participation from retail investors, partly due to easier access through online platforms.
- Initial Public Offerings (IPOs): There was a surge in IPO activity, with several companies going public to raise capital for expansion.
- Foreign Direct Investment (FDI): India remained an attractive destination for Foreign Direct Investment (FDI) in diverse sectors, encompassing technology, e-commerce, and manufacturing.
- Policy Changes: The government introduced a range of policy alterations and initiatives with the goal of enticing foreign investments and enhancing the business environment's ease of operation. Before the covid-19 pandemic, the stock market in India was primarily almost untouched. There was only a dedicated group of retail investors, along with

many foreign institutional investors (FII) and domestic institutional investors (DII). Mainstream media and public knowledge revolved around the risks associated with the stock market while staying oblivious to the opportunities to build long-term wealth. But in 2020, the number of retail investors achieved a sharp spike. The number of active demat account holders rose by 1.4 crores, a figure higher than the previous three years. At a time when businesses shut down and people's livelihoods were impacted, what could have been the possible reasons for an influx of investors in the stock market? Then explore the rise of Indian investors and look at the factors that led to a sudden shift from traditional investment avenues.

In January 2023, there were 110 million demat account holders in India, up significantly from 84 million in 2022. Despite these substantial figures, only around 3% of Indian families are said to be actively involved in the stock market. But as compared to other countries, India's performance is lacking in terms of the number of committed retail investors. Tragically, just 3% of Indians put their money into the stock market. In comparison, 13% of Chinese, 33% of British, and 55% of Americans do similar activities.

The recent developments in the industry have pointed to a positive development. More individual investors were selling their shares before 2019, suggesting they were cautious to acquire more. The net selling of equities was larger than the net buying. However, net purchases increased significantly at the turn of the 2020 calendar year, leading to a net inflow of 51,200 cores (INR). People are becoming more at ease with the stock market and are putting a large portion of their disposable money into shares, as this change in investor behaviour demonstrated.

1. 3. FUNDAMENTAL ANALYSIS

The purpose of fundamental analysis in stock market research is to determine a stock's true value by looking at a number of economic and financial metrics. The process includes looking at things like the company's financials, the condition of the industry, the leadership, the competition, and the macroeconomic data. Finding out if a stock is overpriced or under-priced will help investors make educated decisions about buying or selling. Focusing on a company's fundamental health and performance, rather than just market sentiment or technical chart pattern, is the main focus of this strategy. Financial ratios, indices, and indicators form the backbone of fundamental research.

1. 4. FINANCIAL INDICES

The performance and stability of a firm or the financial market as a whole may be evaluated using financial indices or ratios. By presenting financial data in a consistent and readily digestible manner, they facilitate analysis and comparison. Profitability Ratios gauge "a company's capacity to generate profits concerning its revenue, assets, or equity," and they are one of several common financial rankings or measurements. Some examples are the Net Profit Margin and Return on Investment (ROI). The liquidity ratio is a measure of a company's capacity to meet its short-term obligations using the funds on hand. Solvency Ratios, which measure a company's ability to meet its long-term financial commitments, and the "Current Ratio and Quick Ratio" are two examples. The "Debt to Equity Ratio" and the "Interest Coverage Ratio" serve as examples. "Efficiency Ratios" measure how well a business turns its assets into cash. "Market Ratios" and "Inventory Turnover and Asset Turnover" are two examples of similar tools that may help investors gauge a company's value. Two such metrics are earnings per share ("EPS") and the price-to-earnings (P/E) ratio. Conversely, indices are collective metrics that follow the value of a collection of assets or securities. They provide a snapshot of how a market, industry, or class of assets is doing as a whole. Investors, analysts, and companies rely on financial indices for financial analysis, which in turn aids in decision-making about investments, operations, and strategy.

1. 5. CONTEXT

Financial indices are crucial for fundamental analysis because they provide a snapshot of the overall performance of a specific market, sector, or asset class. Here's why they're important:

- Benchmarking: Indices function as reference points for investors to measure the performance of their investments compared to the overall market or a particular industry. This helps investors assess if their investments are outperforming or underperforming relative to the market.
- Market Trends: They reflect the collective sentiment and trends in the market. Analysing indices can reveal if the market is bullish (rising) or bearish (falling), which can influence investment decisions.
- Diversification: Indices represent a diversified basket of assets. Through an examination of these indices, investors can obtain access to a diverse array of companies or assets without the need to individually invest in each one.
- Risk Assessment: They offer information about the degree of risk linked to a specific market or industry. For instance, a volatile index suggests higher market risk, while a stable one indicates lower risk.
- Sectorial Analysis: Indices are often categorized by sectors (e.g., technology, healthcare, energy). This allows investors to focus on specific industries or areas of interest.
- Investment Strategy: They help investors formulate or adjust their investment strategies. For instance, if an index indicates a strong performance in a particular sector, an investor might allocate more funds to that area.
- Historical Performance: Past performance of an index can provide valuable information about how it might behave in the future. Nonetheless, it's crucial to bear in mind that past performance does not serve as a reliable predictor of future outcomes.
- Liquidity and Accessibility: Many indices have associated exchange-traded funds (ETFs) or mutual funds that track their performance. This provides investors with a convenient way to gain exposure to a specific market or sector.

Financial indices are like vital sign monitors for the financial markets. They offer key metrics that investors can use to make informed decisions about their investments. By tracking indices, investors can stay attuned to market trends and adjust their strategies accordingly. In this context conducting a study on which financial indices are crucial for invest decision making is very pertinent.

1. 6. MULTI-CRITERIA DECISION MAKING

With the use of MCDM approaches, we may organise evaluations and our prioritisations of options according to how well they perform across different criteria. These strategies are incredibly helpful for decision-making and are used extensively in many different areas, including public policy, engineering, economics, environmental management, and business. There are many different MCDM strategies accessible, and each one has its own set of pros and cons. A few examples of popular methods are AHP, TOPSIS, PROMETHEEE, and ELECTRE (Elimination and Choice Expressing Reality). Other popular methods include MARCOS, WASPAS, and ARAS. Researchers have looked at a variety of MCDM methods in the well-known forenamed research. Here, we have some of them like (Taletović, 2023) takes a look at a few well-known MCDM strategies that are commonly used in warehouse management. Choosing logistics distribution channels for delivering the final product: utilizing the FUCOM-MARCOS Model introduced by Stevic et al. (2023). Later on, Krstić et al. (2023) employs an innovative hybrid Multiple Criteria Decision-Making (MCDM) model that combines the best-worst method (BWM) and comprehensive distance-based ranking (COBRA) within a grey analytical framework, enabling a nuanced assessment that accommodates uncertainty effectively. Further, Petrovic et al. (2023) proposed to study Serbia's passenger and freight road transport operational efficacy on an annual basis using Entropy and TOPSIS techniques. The comparing members of the European Union on the logistics performance index: making use of the Bonferroni operator in an integrated MCDM structure explained by Hadžikadunić et al. (2023). Recently, Khan et al. (2024) analyzed strategies for sustainable urban development through the Use of spherical CRITIC-WASPAS models. Chen et al. (2023) developed a method for assessing the carrying capacity of geological environments by employing GIS-AHP analysis. It focuses on 10 indicator layers, encompassing social, ecological, and post-earthquake geological data, as well as disaster distribution and societal evolution. How to use the TOPSIS method to evaluate and prioritise autonomous solutions for sustainable warehouse intra-logistics operations was focused by Dabić-Miletić and Raković (2023). Choosing the most appropriate "MCDM" method depends on the specific characteristics of the decision problem, the availability of data, the complexity" of criteria interactions, and the favours of the decision maker.

1. 7. JUSTIFICATION OF F-AHP

Fuzzy Analytic Hierarchy Process (Fuzzy AHP) (Onay et al., 2016) is a decision-making methodology that extend traditional AHP technique to manage unsteadiness and indeterminacy in decision-making problems. Some justifications for using this technique are Uncertainty and Fuzziness in Decision-making, Subjectivity and Multi-Criteria Decision Making, Inconsistent and Incomplete Data, Trade-offs and Ranking, Flexible Modelling, Complex Decision Scenarios, Project Evaluation and Selection, Risk Assessment, Sensitivity Analysis, Applicability in Various Fields. In shorts, the justification for using Fuzzy AHP lie in their ability to handle uncertainty, subjective preferences, multi-criteria decision-making, and complex decision scenarios, making them valuable tools for making informed and robust decisions in real-world situations.

1. 8. BENEFICIARIES

The potential beneficiaries could include for conduct research on the stock market:

- **Investors**: They can make more informed decisions about buying, selling, or holding stocks.
- **Traders**: They can use your research for short-term trading strategies.
- **Financial Analysts**: Your findings could aid in their market analyses and forecasts.
- **Academics**: Your research has the potential to add to the existing knowledge base in the fields of finance and economics.
- **Financial Advisors**: They can use your insights to provide better advice to their clients.
- **Regulators**: Your research may provide insights into market trends and behaviors, aiding in policy decisions.
- **Companies**: They may use your research to understand investor sentiment and market dynamics.
- **General Public**: Those interested in finance can gain a better understanding of the market through your research.

Though the impact and relevance of any research will depend on its quality, originality and applicability.

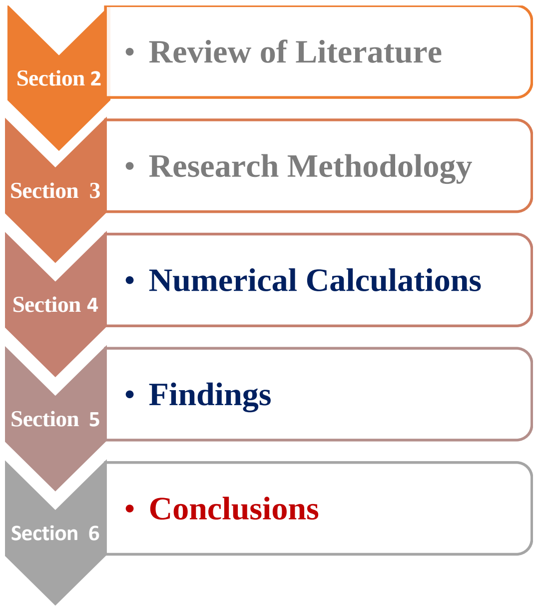
1. 9. NOVELTIES

The novelty in our research lies in applying Fuzzy AHP to evaluate and give precedence to financial indices. This approach introduces a quantitative and systematic method for determining the relative importance of different financial indicators, potentially offering more nuanced and accurate insights for decision-making in financial analysis as well as investment point of view.

1. 10. STRUCTURE OF THE STUDY

The rest portion of the paper is set for the following way as presented in the figure 1:

Figure 1. Structure of the study



Source: Own creation

2. REVIEW OF LITERATURE

After conducting an extensive literature review, this study has noted that numerous research endeavours have been undertaken across diverse fields of finance and other industries, employing a range of MCDM techniques to address multi-criteria decision-making challenges. Various MCDM approaches are available for conducting comparative analyses and establishing rankings. Researchers have adopted different combinations of these methods based on their specific study's requirements to determine the most suitable alternative.

Table 1. An extensive Review of Literature

Authors	Methodology Applied	Objectives
(Gallizo et al., 2002)	Bayesian hierarchical model based on the partial adjustment model	Analyse financial ratios through the Central Balance Sheet Office (CBSO) of The Bank of Spain.
(Laitinen, 2006)	Financial statement method	Evaluate Nokia's prospective growth from 1990 to 2000.

Authors	Methodology Applied	Objectives
(Johnson et al., 2006)	AHP	Choose the authentication level that best fits your needs and preferences.
(Öcal et al., 2007)	Factor analysis	Identifying financial metrics for assessing the financial trajectory of the Turkish construction sector over a five-year span is crucial.
(Shiue et al., 2008)	Empirical experimentation	To evaluate the financial well-being of 537 companies that are publicly traded on the Taiwan Stock Exchange Corporation.
(Wang et al., 2008)	Clustering method	Group financial ratios from various companies based on similar fluctuations.
(Sun & Li, 2009)	Financial distress prediction (FDP) method	Efforts are made to propose a serial combination system involving multiple classifiers, leveraging the class-specific expertise of diverse base classifiers.
(Xidonas et al., 2009)	ELECTRE Tri	In the process of choosing stocks through financial analysis, the selection of equities is conducted.
(Zangoueinezhad & Moshabaki, 2011)	Fuzzy multiple attribute decision making (FMADM)	To assess the effectiveness of a university across the four knowledge-based dimensions of a balanced scorecard, one can evaluate its performance.
(Kung et al., 2011)	Fuzzy AHP & Fuzzy TOPSIS	Identify the most fitting company among the five options.
(Low & Hsueh Chen, 2012)	FAHP & Fuzzy Delphi method (FDM)	To assess the main metric obtained from 188 valid responses at an operational hospital in Taiwan.
(Seruffo et al., 2012)	fuzzy AHP & TOPSIS & ELECTRE III	In the context of the integrated services digital broadcasting terrestrial standard, when choosing the initial connection point for access, it is crucial to maintain a high standard of service quality. This is particularly important when employing a videoconferencing application for seamless communication.
(Božanić et al., 2015)	Modified AHP	Fuzzy numbers are utilised to establish the weights of the criterion and alternative values since they are great at expressing ambiguity and uncertainty. Following the AHP procedure, we were able to ascertain criteria function values for all of the options that were considered; these values were in line with the values dictated by the level of conviction.
(Božanić et al., 2016)	fuzzy AHP, MABAC	So that we may rank the options and get the weight coefficients of the criterion. When deciding where to set up laying-up positions, this hybrid approach might help with decision making.
(Ghosh & Jana, 2017)	VIKOR	To assess and contrast the financial success of nine information technology firms listed on the National Stock Exchange in India.
(Ghunaim & Dichter, 2019)	(FAHP) & KNIME data mining platform	To choose the optimal classifier for software development projects.
(Nazzal et al., 2019)	SPSS program	To identify the predominant histological subtypes of breast cancer in the West Bank region of Palestine, one would seek to determine the most frequently observed tissue patterns in cancerous breast cells.

Authors	Methodology Applied	Objectives
(Jana et al., 2019)	Data Envelopment Analysis (DEA)	To ascertain the suitable timing for adjusting the portfolio.
(Prajapati et al., 2020)	Fuzzy AHP and fuzzy TOPSIS	Enhance the current maritime model to facilitate seamless connections between industry professionals and logistics firms in the maritime sector.
(Bobar et al., 2020)	Fuzzy AHP-Z Number Model - Fuzzy MABAC	To find the Ranking and Assessment of the Efficiency of Social Media
(Bajec & Tuljak-Suban, 2019)	MCDM	In choosing a third-party logistics provider (3PLP), the process involves selecting a suitable external partner for managing and optimizing various aspects of logistics and supply chain activities.
(Jana, 2021)	MAGDM method -bipolar fuzzy MABAC	For the selection of renewable energy power generation project.
(Ghorui et al., 2021)	AHP, TOPSIS, WASPAS, SAW	Evaluation of performance for School Teacher Recruitment using
(Kumar & Nagarajan, 2021)	FAHP	To identify a suitable resolution for distributing spectrum among secondary users.
(Ghosh et.al., 2021)	DEA & Structural Equation Modelling (SEM)	To assess the operational effectiveness of life insurance companies operating in India from 2010 to 2017.
(Jana & Basu, 2021)	TOPSIS	To assess the financial well-being of pharmaceutical companies operating in the Indian market.
(Ala et al., 2023)	Neutrosophic-Based Multi-Objective Grey Wolf Optimizer	For Ensuring the Security and Resilience of Sustainable Energy
(Bozanic et al., 2023)	Modified AHP with TFN	The goal of this presentation is to shed light on the challenge of determining a ship's navigational path through flooded regions by weighing the potential hazards associated with each potential route.
(Jana et al., 2023)	Linguistic q-rung orthopair fuzzy Choquet integral approach	In this study, the authors tackle the problem of how to choose the most environmentally friendly method of urban package distribution. Its goal is to facilitate the discovery of a solution that is ecologically sound, socially responsible, and economically feasible for postal and logistics corporations, regulatory bodies, and municipal authorities.
(Sharma et al., 2023)	AHP	To create a design for a forging die.
(Nandi et al., 2023)	HFS, GHFS, GHPFN, GHPFN TOPSIS	Evaluation of the treatment options for COVID-19 patients
(Shekar& Mathew, 2023)	Fuzzy AHP	Utilizing a combination of methodologies to evaluate groundwater potential zones (GWPZs) and pinpoint appropriate locations for artificial recharge sites.
(Jana et al., 2023)	Type-2 fuzzy VIKOR method	The goal of this paper is to present an improved extended version of interval type-2 fuzzy VIKOR method for relieving the drawbacks of usual IT2FVIKOR.
(Baskaran et al., 2023)	AHP and GIS technique	Evaluation of land appropriateness for agricultural purposes.
(Jana et al., 2024)	Hybrid MCDM method - bipolar fuzzy approach	For economic condition analysis.

Source: Own creation

The objectives of this study are

(i) To find the most important financial indices for investment point of view.

(ii) To find the weightage of importance of selected financial Indices.

3. RESEARCH METHODOLOGY

3. 1. SELECTION OF CRITERIA

In this study, we initially compile a set of performance assessment metrics derived from financial statement indicators and ratios. Subsequently, we conduct a survey involving SEBI registered financial advisors and experts. The questionnaire is structured in accordance with the AHP format and encompasses the aforementioned financial statement ratios. The outcomes aim to offer insights and guidance to investors for shaping their future investment strategies. To identify the primary criteria, six SEBI registered experts were enlisted to participate in the survey.

After taking the experts opinion the four financial indices were considered for this study such as Price Earnings to Growth ratio (PEG), Price to Book Value (PB), Debt-Equity Ratio (DE) and Dividend Yield (DY) which are most important for fundamental analysis of a stock.

In Table 2, formulas for financial indices are defined.

Table 2. Formula for selected Financial Indices (Criteria)

Financial Indices	Formula
$Price\ Earning\ to\ Growth\ Rat$	$Price\ Earning\ to\ Growth\ Ratio = \frac{Price\ to\ Earnings\ Ratio}{Earnings\ Growth\ Rate}$
$Debt\ to\ Equity\ Ratio\ (PB)$	$Debt\ to\ Equity\ Ratio = \frac{Total\ Debt}{Total\ Shareholders'\ Equity}$
$Price\ to\ Book\ Value\ (DE)$	$Price\ to\ Book\ Value = \frac{Market\ Price\ per\ Share}{Book\ Value\ per\ Share}$
$Dividend\ Yield\ (DY)$	$Dividend\ Yield = \frac{Dividend\ per\ Share}{Market\ Price\ per\ Share}$

Source: Own creation

3. 2. ARITHMETIC OPERATIONS OF TFN

Fuzzy set theory was introduced by Zadeh, (1965).

Let $E = (e_1, e_2, e_3)$ and $F = (f_1, f_2, f_3)$ be two different TFN.

(a) Addition:

$$(E + F) = (e_1 + f_1, e_2 + f_2, e_3 + f_3) \tag{1}$$

(b) Subtraction:

$$(E - F) = (e_1 - f_3, e_2 - f_2, e_3 - f_1) \tag{2}$$

(c) Multiplication:

$$(E \times F) = (e_1 f_1, e_2 f_2, e_3 f_3) \tag{3}$$

(d) Scalar Multiplication:

$$\theta E = (\theta e_1, \theta e_2, \theta e_3) \tag{4}$$

(e) Division:

$$\left(\frac{E}{F}\right) = \left(\frac{e_1}{f_3}, \frac{e_2}{f_2}, \frac{e_3}{f_1}\right) \tag{5}$$

(f) Inverse:

$$E^{-1} = \left(\frac{1}{e_3}, \frac{1}{e_2}, \frac{1}{e_1}\right) \tag{6}$$

3. 3. FUZZY AHP

The AHP, introduced by Saaty in 1980 offers a framework for evaluating the relative significance of various activities within a multi-criteria decision-making context (Saaty, 1980). It relies on pairwise comparisons for its assessments. In 1983, Van Laarhoven and Pedrycz, present a fuzzy method for choosing among a number of alternatives under conflicting decision criteria (Van Laarhoven et. al., 1983).

Two most popular Fuzzy AHP methods which are used to calculate the weights of the criteria are:

(i) Geometric Mean Method of Fuzzy AHP (GMM F-AHP):

It was introduced by Buckley, (1985).

(ii) Extent Analysis Method of Fuzzy AHP (EAM F-AHP):

It was introduced by Chang in 1996 Chang, (1996).

Nevertheless, the conventional AHP model encounters certain issues as identified by Yang and Chen in 2004. They noted that AHP is primarily suited for situations with well-defined data, leading to a potentially skewed and imprecise judgment scale (Yang & Chen, 2004). Furthermore, the subjective opinions and preferences of decision makers heavily influence the outcomes of AHP. To address these concerns, several researchers have integrated fuzzy theory with AHP in order to enhance its handling of uncertainty (Fattoruso et. el., 2022). Researchers are concentred their presently in some complex intelligent decision-making problems related AHP (Fattoruso et. el., 2022) and TOPSIS model (Modibbo et. al., 2022).

3. 3. 1. STEPS OF GMM F-AHPStep 1: Develop Traditional Hierarchical Structure

The AHP involves decomposing a complex problem into smaller parts, creating a hierarchical structure. This structure consists of a top level representing the primary goal, a second level for criteria, and the lowest level for decision alternatives. The hierarchy can extend beyond three levels, with the top level signifying the overarching goal, the second level encompassing criteria, and the lowest level comprising alternatives. Additional levels may incorporate sub-criteria.

Step 2: Create Pair-wise Comparison Matrix with Scale of relative importance

Construct fuzzy pair-wise comparison matrices of order n*n, if there are m criteria. Through expert questionnaires, each expert is asked to assign linguistic terms by TFN.

The elements a_{ij} can be placed as the degree of preferences of *ith* criterion over *jth* criterion.

Step 3: Construct Fuzzified Pairwise Comparison Matrix

In this step, to get fuzzified comparison matrix we have to transfer real elements of A into fuzzy numbers.

$$A = \begin{bmatrix} \tilde{a}_{11} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & \tilde{a}_{22} & & \tilde{a}_{2n} \\ \vdots & & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{a}_{nn} \end{bmatrix}$$

Step 4: Computation of Fuzzy Geometric Mean Value for each criterion

Geometric Mean Method, proposed by Buckley, (1985), is used to find geometric mean value of the fuzzy comparison values of criterion for each criterion by using the Equation (7)

$$\tilde{r}_i = \left((r_{11} * r_{21} * \ldots * r_{n1})^{\frac{1}{n}}, (r_{12} * r_{22} * \ldots * r_{n2})^{\frac{1}{n}} \ldots\ldots\ldots (r_{1n} * r_{2n} * \ldots * r_{nn})^{\frac{1}{n}} \right) = (r_{i1}, r_{i2}, \ldots, r_{in}) \tag{7}$$

Step 5: Compute the fuzzy weights $(\widetilde{w}_i)$

This step is dedicated for finding out the fuzzy weights for every criterion by using the formula

$$\widetilde{w}_i = \tilde{r}_i \otimes \{\tilde{r}_1 \oplus \tilde{r}_2 \oplus \ldots\ldots \oplus \tilde{r}_n\}^{-1} \tag{8}$$

Step 6: De-Fuzzification

This step has performed to De-Fuzzify the fuzzy weights by using the formula of "Centre of Area (COA)" and Best Non-fuzzy Performance (BNP) both.

$$Centre\ of\ Area\ (COA) = w_i = \left(\frac{l+m+u}{3}\right) \tag{9}$$

$$BNP_{ci} = \frac{[(U_{Wi} - L_{Wi}) + (M_{Wi} - L_{Wi})]}{3} + L_{Wi} \tag{10}$$

Step7: Normalization of Weights

If the total criteria weight is greater than 1, it is not acceptable. So the weights are generally normalized to get the total weights 1.

3. 3. 2. STEPS OF EAM F-AHP:

Step 1: Create Pairwise Comparison Matrix with Scale of relative importance

Construct fuzzy pair-wise comparison matrices of order n*n, if there are m criteria. Through expert questionnaires, each expert is asked to assign linguistic terms by TFN.

The elements a_{ij} can be placed as the degree of preferences of *ith* criterion over *jth* criterion.

Step 2: Construct Fuzzified Pairwise Comparison Matrix

In this step, to get fuzzified comparison matrix we have to transfer real elements of A into fuzzy numbers.

$$A = \begin{bmatrix} \tilde{a}_{11} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & \tilde{a}_{22} & & \tilde{a}_{2n} \\ \vdots & & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{a}_{nn} \end{bmatrix} \tag{11}$$

Step 3: Calculate the Fuzzy Synthetic Extent

In this step we have to calculate fuzzy synthetic extent with respect to i^{th} alternative by the following formula:

$$S_i = \sum_{j=1}^{n} \tilde{a}_{ij}\left[\sum_{i=1}^{n}\sum_{j=1}^{n} \tilde{a}_{ij}\right]^{-1} \tag{12}$$

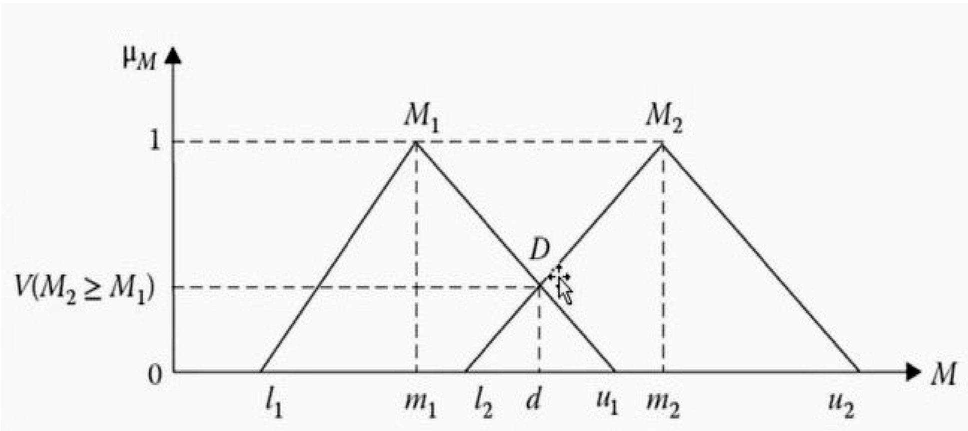
Step 4: Calculate the degree of possibility

Two Fuzzy numbers are compared so as to get the degree of possibility of one fuzzy number greater than other fuzzy number. Suppose we have two Fuzzy numbers $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$. Then the degree of possibility of $M_2 \geq M_1$ is calculated using the following formula:

$$V(M_2 \geq M_1) = \sup\left[\min\left(\mu_{M_1(x)}, \mu_{M_2(y)}\right)\right] = hgt\,(M_1 \cap M_2) = \mu_{M_2(d)}$$
$$= \begin{cases} 1; & if\ m_2 \geq m_1 \\ 0; & if\ l_1 \geq u_2 \\ \frac{(l_1-u_2)}{(m_2-u_2)-(m_1-l_1)}; & otherwise \end{cases} \tag{13}$$

Where $M_1 = (l_1, m_1, u_1)$ *and* $M_2 = (l_2, m_2, u_2)$

Figure 2. Degree of Possibility in Diagram



Source: (Hangshenas et. al., 2017)

In the Figure 2, d is the ordinate of the highest intersection point between M_1 and M_2. We can visualize D is the highest intersection point. In the figure l_1, m_1 *and* u_1 are the ordinates of the membership function M_1. Also l_2, m_2 *and* u_2 are the ordinates of the membership function M_2.

Step 5: Calculate the degree of possibility for a convex fuzzy number to be greater than k convex fuzzy number

In this step we have to calculate the value of *V*. These values will be calculated by using the following formula:

$$V(S \geq S_1, S_2, \ldots\ldots, S_k) = \min V\,(S \geq S_i),\ where\ i = 1,2, \ldots\ldots k; \tag{14}$$

Step 6: Calculate the weight vector and normalize the non-fuzzy weight vector

Now we use the following formula:

$$d'(A_i) = \min \mathrm{V}\,(S_i \geq S_k),\ i, k = 1,2, \ldots\ldots, n;\ k \neq i; \tag{15}$$

$$W' = \{d'(A_1), d'(A_2), \ldots\ldots\ldots d'(A_n)\}^T; \tag{16}$$

3. 3. 3. CONSISTENCY CHECK

In this step we have to check the whether the calculated values of weights are usable or not. For this we have to take the same pair-wise comparison matrix which is not normalized. First we have to calculate Consistency Index (C.I) by the following formula:

$$\text{Consistency Index (C.I)} = \frac{\lambda_{max} - n}{n-1} \tag{17}$$

$$\text{Where } \lambda_{max} = \frac{\sum_{i=1}^{n} \frac{WSV_i}{CW_i}}{n} \tag{18}$$

and n is the number of compared elements. Here *WSV & CW* stands for Weighted Sum Value and Criteria weights respectively.

Now we have to calculate the Consistency Ratio (C.R) by the following formula:

$$\text{Consistency Ratio} = \frac{\text{Consistency Index (C.I)}}{\text{Random Index (R.I)}} \tag{19}$$

We will take the value of RI from provided table of RI.

If we find the C.R value lees than 0.10, pairwise matrix is reasonably consistent. Here 0.10 is the standard value as AHP allows up to 10% inconsistency. If the inconsistency is more than 10%, then matrix needs to be reconsidered. If the check of consistency is ok, the criteria weights can be used by the decision maker for their further calculations. So the pairwise comparison matrix is reasonably consistent. Otherwise we have to reconstruct the pairwise comparison matrix.

4. NUMERICAL CALCULATIONS

Firstly we have to define a Scale of Relative Importance according to degree of importance. In Table 3 it is defined.

Table 3. Scale of Relative Importance

Degree of importance	Definition
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2, 4, 6, 8	Intermediate values
$\frac{1}{3}, \frac{1}{5}, \frac{1}{7}, \frac{1}{9}$	Values for inverse comparison

Source: (Saaty, 1980)

Now Pair-wise comparison matrix is created with the help of “Scale of Relative Importance”. The Pair-wise comparison matrix gives relative importance of different criteria with respect to goal. Here we have 4×4 matrix as we have 4 criteria.

To calculate the value in each cell:

- Now what will be the value in (PEG, PB) cell?

To the experts PEG is "strong importance" than PB (It may vary person to person). If PB is x, then PEG is 5x.

$$Value\ (PEG, PB) = \frac{Row\ element}{Coloumn\ element} = \frac{5x}{x} = 5$$

$$Value\ (PB, PEG) = \frac{1}{5}$$

- Now what will be the value in (PEG, DE) cell?

To the experts PEG is "moderate to strong importance" than DE (It may vary person to person). If DE is x, then PEG is 4x.

$$Value\ (PEG, DE) = \frac{Row\ element}{Coloumn\ element} = \frac{4x}{x} = 4$$

$$Value\ (DE, PEG) = \frac{1}{4}$$

- Now what will be the value in (DE, PB) cell?

To the experts DE is "equal to moderate importance" than PB (It may vary person to person). If PB is x, then DE is 2x.

$$Value\ (DE, PB) = \frac{Row\ element}{Coloumn\ element} = \frac{2x}{x} = 2$$

$$Value\ (PB, DE) = \frac{1}{2}$$

Similarly it can be assigned the values to each cell. In Table 4 the complete pair-wise comparison matrix is presented.

Table 4. Pair-wise Comparison Matrix

Criteria	PEG	PB	DE	DY
PEG	1	5	4	7
PB	$\frac{1}{5}$	1	$\frac{1}{2}$	3
DE	$\frac{1}{4}$	2	1	3
DY	$\frac{1}{7}$	$\frac{1}{3}$	$\frac{1}{3}$	1

Source: Own calculation

In the context of relative importance scales, crisp numeric values such as 1, 3, 5, 7, and 9 are commonly observed. In Fuzzy Logic, these precise numerical values undergo a transformation into Fuzzy numbers. This involves the conversion of linguistic terms into membership functions, where the triangular segment within the given figure is recognized as the triangular membership function. This particular membership function assumes a triangular shape, hence its name.

It is important to note that Triangular Membership Function is just one type among various others, including Trapezoidal membership function, Bell-shaped membership function, etc. The Fuzzy value is generally represented as $\mu_A(x) = \tilde{A}=(1,2,3)$, *here 1,2,3* together known as Fuzzy number which is associated with the membership function. This approach addresses the limita-

tion of assigning a single numeric value to a term. For instance, designating “Moderate” with the value 3 may not adequately capture the nuances between 2.5 and 3.5. The introduction of Fuzzy numbers resolves this issue by accommodating a range of values, allowing for a more nuanced and flexible representation of linguistic terms in the Fuzzy Logic framework.
In the Table 5 Fuzzy Scale of Relative Importance is defined. Here the crisp numbers like 1, 3, 5, 7 and 9 is replaced with the Fuzzy number.

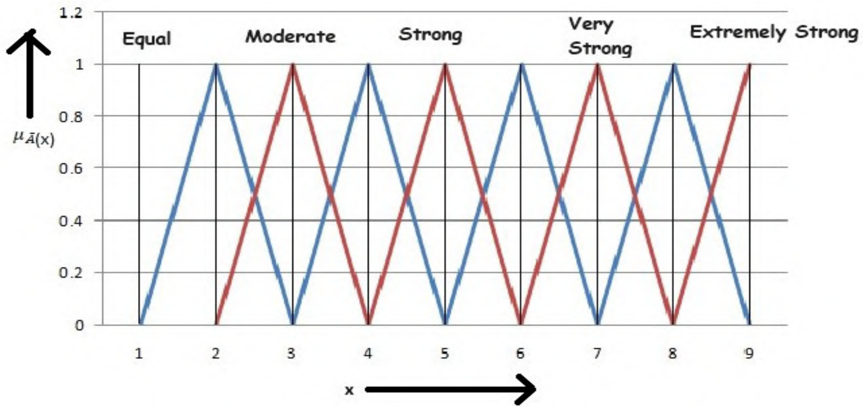
Table 5. Fuzzy Scale of Relative Importance

Linguistic Terms	Fuzzy Numbers
Equal	*(1, 1, 1)*
Moderate	*(2, 3, 4)*
Strong	*(4, 5, 6)*
Very Strong	*(6, 7, 8)*
Extremly Strong	*(9, 9, 9)*
Intermediate Values	*(1, 2, 3)*
	(3, 4, 5)
	(5, 6, 7)
	(7, 8, 9)

Source: Zavadskas et al. (2020)

In the Figure 3 diagram of Fuzzy Scale of Relative Importance sketched.

Figure 3. Diagram of Fuzzy Scale of Relative Importance



Source: (Hsieh et al. 2015)

In the Table 6 Crisp & Fuzzy Scale of Relative Importance represented together.

Table 6. Crisp & Fuzzy Scale of Relative Importance together

Linguistic Terms	Crisp Numbers	Fuzzy Numbers
Equal	*1*	(1, 1, 1)
Moderate	*3*	(2, 3, 4)
Strong	*5*	(4, 5, 6)
Very Strong	*7*	(6, 7, 8)
Extremly Strong	*9*	(9, 9, 9)
Intermediate Values	*2*	(1, 2, 3)
	4	(3, 4, 5)
	6	(5, 6, 7)
	8	(7, 8, 9)

Source: Zavadskas et al. (2020)

Table 7 replacing the crisp numeric value to the Fuzzy numbers in the Pair-wise comparison matrix to get the Fuzzified Pair-Wise comparison matrix.

Table 7. Fuzzified Pair-Wise comparison matrix

Criteria	PEG	PB	DE	DY
PEG	(1, 1, 1)	(4, 5, 6)	(3, 4, 5)	(6, 7, 8)
PB	$\left(\frac{1}{6}, \frac{1}{5}, \frac{1}{4}\right)$	(1, 1, 1)	$\left(\frac{1}{3}, \frac{1}{2}, \frac{1}{1}\right)$	(2, 3, 4)
DE	$\left(\frac{1}{5}, \frac{1}{4}, \frac{1}{3}\right)$	(1, 2, 3)	(1, 1, 1)	(2, 3, 4)
DY	$\left(\frac{1}{8}, \frac{1}{7}, \frac{1}{6}\right)$	$\left(\frac{1}{4}, \frac{1}{3}, \frac{1}{2}\right)$	$\left(\frac{1}{4}, \frac{1}{3}, \frac{1}{2}\right)$	(1, 1, 1)

Source: Own calculation

4. 1. CALCULATIONS WITH GMM F-AHP

Geometric Mean Method of Fuzzy AHP (GMM F-AHP) is used to calculate the weights of the criteria.

$\widetilde{P} \otimes \widetilde{Q} = (l_1 \otimes l_2, m_1 \otimes m_2, u_1 \otimes u_2)\ where\ l_1 \geq 0, l_2 \geq 0$. This is equation used to multiply two fuzzy numbers. Table 8 calculates the Fuzzy Geometric Mean Value using Equation (7).

Table 8. Calculation of Fuzzy Geometric Mean Value

Criteria	PEG	PB	DE	DY	Fuzzy Geometric Mean Value ($\tilde{r}_i$)
PEG	$(1, 1, 1)$	$(4, 5, 6)$	$(3, 4, 5)$	$(6, 7, 8)$	$(2.91, 3.44, 3.94)$
PB	$\left(\frac{1}{6}, \frac{1}{5}, \frac{1}{4}\right)$	$(1, 1, 1)$	$\left(\frac{1}{3}, \frac{1}{2}, \frac{1}{1}\right)$	$(2, 3, 4)$	$(0{,}58, 0.74, 1)$
DE	$\left(\frac{1}{5}, \frac{1}{4}, \frac{1}{3}\right)$	$(1, 2, 3)$	$(1, 1, 1)$	$(2, 3, 4)$	$(0.80, 1.11, 1.41)$
DY	$\left(\frac{1}{8}, \frac{1}{7}, \frac{1}{6}\right)$	$\left(\frac{1}{4}, \frac{1}{3}, \frac{1}{2}\right)$	$\left(\frac{1}{4}, \frac{1}{3}, \frac{1}{2}\right)$	$(1, 1, 1)$	$(0.30, 0.35, 0.45)$

Source: Own calculation

$\tilde{r}_1 = \left((1 * 4 * 3 * 6)^{\frac{1}{4}}, (1 * 5 * 4 * 7)^{\frac{1}{4}}, (1 * 6 * 5 * 8)^{\frac{1}{4}}\right) = (2.91, 3.44, 3.94)$ and so on.

Next the Fuzzy weights for every criterion are calculated in Table 9 using the Equation (8) i.e.

$$\tilde{w}_i = \tilde{r}_i \otimes \{\tilde{r}_1 \oplus \tilde{r}_2 \oplus ..... \oplus \tilde{r}_n\}^{-1}$$

Table 9. Calculation of Fuzzy weights for every criterion

Criteria	Fuzzy Geometric Mean Value ($\tilde{r}_i$)	Fuzzy Weights ($\tilde{w}_i$)
PEG	(2.91, 3.44, 3.94)	$(2.91, 3.44, 3.94) \otimes \left(\frac{1}{6.80}, \frac{1}{5.64}, \frac{1}{4.58}\right) = (0.43, 0.61, 0.86)$
PB	(0.58, 0.74, 1)	$(0.58, 0.74, 1) \otimes \left(\frac{1}{6.80}, \frac{1}{5.64}, \frac{1}{4.58}\right) = (0.08, 0.13, 0.22)$
DE	(0.80, 1.11, 1.41)	$(0.80, 1.11, 1.41) \otimes \left(\frac{1}{6.80}, \frac{1}{5.64}, \frac{1}{4.58}\right) = (0.12, 0.20, 0.31)$
DY	(0.30, 0.35, 0.45)	$(0.30, 0.35, 0.45) \otimes \left(\frac{1}{6.80}, \frac{1}{5.64}, \frac{1}{4.58}\right) = (0.04, 0.06, 0.09)$

Source: Own calculation

$$(\tilde{r}_1 \oplus \tilde{r}_2 \oplus \tilde{r}_3 \oplus \tilde{r}_4)^{-1} = \left(\frac{1}{6.80}, \frac{1}{5.64}, \frac{1}{4.58}\right)$$

$$\tilde{A}_1 \otimes \tilde{A}_2 = (l_1, m_1, u_1) \otimes (l_2, m_2, u_2) = (l_1 * l_2, m_1 * m_2, u_1 * u_2)$$

Now we have to De-Fuzzify these four Fuzzy Numbers to get crisp numerical values. Table 10 shows the value of crisp weight after doing De-Fuzzification by using Equation (10) i.e. $Centre\ of\ Area\ (COA) = w_i = \left(\frac{l+m+u}{3}\right)$ and Equation (10) i.e. both simultaneously. Then took mean of COA & BNP.

Table 10. Crisp Weight after De-Fuzzification

Criteria	Fuzzy Weights ($\tilde{w}_i$)	Crisp Weight (w_i) (COA)	Crisp Weight (w_i) (BNP)	Mean $w_i = \frac{COA+BNP}{2}$
PEG	(0.43, 0.61, 0.86)	0.633	0.633	0.633
PB	(0.08, 0.13, 0.22)	0.145	0.143	0.144
DE	(0.12, 0.20, 0.31)	0.207	0.210	0.208
DY	(0.04, 0.06, 0.09)	0.068	0.063	0.066
				$Total = 1.058$

Source: Own calculation

$$COA_{PEG} = \frac{0.43 + 0.61 + 0.86}{3} = 0.633\ and\ BNP_{PEG} = \frac{[(0.86 - 0.43) + (0.61 - 0.43)]}{3} + 0.43 = 0.633$$

Now in the Table 10 we can see that the total criteria weight is 1.058 which is not acceptable as it is greater than 1. So the weights are generally normalized to get the total weights 1.

Table 11. Normalized Weight

Criteria	Crisp Weight (w_i)	Normalized Weight
PEG	0.633	$\frac{0.633}{1.058} = \mathbf{0.640}$
PB	0.144	$\frac{0.144}{1.058} = \mathbf{0.162}$
DE	0.208	$\frac{0.208}{1.058} = \mathbf{0.170}$
DY	0.066	$\frac{0.066}{1.058} = \mathbf{0.028}$
	$Total = 1.058$	$Total = 1$

Source: Own calculation

In the Table 11 the weights are normalized by dividing each weight by the total weight i.e. 1.058. Now the sum of the normalized weights is 1.

4. 2. CALCULATIONS WITH EAM F-AHP

First we have to choose the pairwise comparison matrix as represented in Table 7.

Firstly we have to calculate the value of $\sum_{j=1}^{n} \tilde{a}_{ij}$ as shows in Table 12.

Table 12. Calculation of $\sum_{j=1}^{n} \tilde{a}_{ij}$

Criteria	PEG	PB	DE	DY	$\sum_{j=1}^{n} \tilde{a}_{ij}$
PEG	(1, 1, 1)	(4, 5, 6)	(3, 4, 5)	(6, 7, 8)	(14, 17, 20)
PB	$\left(\frac{1}{6}, \frac{1}{5}, \frac{1}{4}\right)$	(1, 1, 1)	$\left(\frac{1}{3}, \frac{1}{2}, \frac{1}{1}\right)$	(2, 3, 4)	(3.50, 4.70, 6.25)
DE	$\left(\frac{1}{5}, \frac{1}{4}, \frac{1}{3}\right)$	(1, 2, 3)	(1, 1, 1)	(2, 3, 4)	(4.20, 6.25, 8.33)
DY	$\left(\frac{1}{8}, \frac{1}{7}, \frac{1}{6}\right)$	$\left(\frac{1}{4}, \frac{1}{3}, \frac{1}{2}\right)$	$\left(\frac{1}{4}, \frac{1}{3}, \frac{1}{2}\right)$	(1, 1, 1)	(1.62, 1.81, 2.17)
					$\sum_{i=1}^{n}\sum_{j=1}^{n} \tilde{a}_{ij} = (23.32, 29.76, 36.75)$
					$\left[\sum_{i=1}^{n}\sum_{j=1}^{n} \tilde{a}_{ij}\right]^{-1} = \left(\frac{1}{36.75}, \frac{1}{29.76}, \frac{1}{23.32}\right)$

Source: Own calculation

Now we have to calculate the fuzzy synthetic extent as shown in Table 13 with respect to alternative by using Equation (12).

Table 13. Calculation of Fuzzy Synthetic Extent

Criteria	$\sum_{j=1}^{n} \tilde{a}_{ij}$	$\sum_{j=1}^{n} \tilde{a}_{ij} \left[\sum_{i=1}^{n}\sum_{j=1}^{n} \tilde{a}_{ij}\right]^{-1}$	S_i (Fuzzy Synthetic Extent)
PEG	(14, 17, 20)	$(14, 17, 20) \otimes \left(\frac{1}{36.75}, \frac{1}{29.76}, \frac{1}{23.32}\right)$	$S_1 = (0.38, 0.57, 0.86)$
PB	(3.50, 4.70, 6.25)	$(3.50, 4.70, 6.25) \otimes \left(\frac{1}{36.75}, \frac{1}{29.76}, \frac{1}{23.32}\right)$	$S_2 = (0.09, 0.16, 0.27)$
DE	(4.20, 6.25, 8.33)	$(4.20, 6.25, 8.33) \otimes \left(\frac{1}{36.75}, \frac{1}{29.76}, \frac{1}{23.32}\right)$	$S_3 = (0.11, 0.21, 0.36)$
DY	(1.62, 1.81, 2.17)	$(1.62, 1.81, 2.17) \otimes \left(\frac{1}{36.75}, \frac{1}{29.76}, \frac{1}{23.32}\right)$	$S_4 = (0.04, 0.06, 0.09)$

Source: Own calculation

Therefore $l_1 = 0.38, m_1 = 0.57, u_1 = 0.86, l_2 = 0.09, m_2 = 0.16, u_2 = 0.27,$
$l_3 = 0.11, m_3 = 0.21, u_3 = 0.36, l_4 = 0.04, m_4 = 0.06, u_4 = 0.09$

Now we are going to calculate the degree of possibility using equation (13). Here we need to calculate the twelve degree of possibility as we have four criteria. They are

$V(S_1 \geq S_2) = 1;$ *Since* $m_1 > m_2$

$V(S_1 \geq S_3) = 1;$ *Since* $m_1 > m_3$

$V(S_1 \geq S_4) = 1;$ *Since* $m_1 > m_4$

$V(S_2 \geq S_1) = 1;$ *Since* $l_1 > u_2$

$V(S_2 \geq S_3) = 0.197$

$V(S_2 \geq S_4) = 1;$ *Since* $m_2 > m_4$

$V(S_3 \geq S_1) = 0.401$

$V(S_3 \geq S_2) = 1;$ *Since* $m_3 > m_2$

$V(S_3 \geq S_4) = 1;$ *Since* $m_3 > m_4$

$V(S_4 \geq S_1) = 1;$ *Since* $l_1 > u_4$

$V(S_4 \geq S_2) = 1;$ *Since* $l_2 > u_4$

$V(S_4 \geq S_3) = 0.181$

Now we have to calculate the value of $V(S_1 \geq S_2, S_3, S_4)$, $V(S_2 \geq S_1, S_3, S_4)$, $V(S_3 \geq S_1, S_2, S_4)$, $V(S_4 \geq S_1, S_2, S_3)$ by using equation (14)

$V(S_1 \geq S_2, S_3, S_4) = 1;$ *Since the minimum value of* $V(S_1 \geq S_2) = 1$, $V(S_1 \geq S_3) = 1$ *and* $V(S_1 \geq S_4) = 1$ *is 1*

$V(S_2 \geq S_1, S_3, S_4) = 0.197;$ *Since the minimum value of* $V(S_2 \geq S_1) = 1$, $V(S_2 \geq S_3) = 0.197$ *and* $V(S_2 \geq S_4) = 1$ *is 0.197*

$V(S_3 \geq S_1, S_2, S_4) = 0.401;$ *Since the minimum value of* $V(S_3 \geq S_1) = 0.401$, $V(S_3 \geq S_2) = 1$ *and* $V(S_3 \geq S_4) = 1$ *is 0.401*

$V(S_4 \geq S_1, S_2, S_3) = 0.181;$ *Since the minimum value of* $V(S_4 \geq S_1) = 1$, $V(S_4 \geq S_2) = 1$ *and* $V(S_4 \geq S_3) = 0.181$

Now by applying Equation (15) and Equation (16) we have to calculate the weight vector and normalize the non-fuzzy weight vector.

Therefore $W' = \left(\frac{1}{1.779}, \frac{0.197}{1.779}, \frac{0.401}{1.779}, \frac{0.181}{1.779}\right)^T = (0.562, 0.111, 0.225, 0.102)^T$

Table 14. Non-Fuzzified Criteria Weights

Criteria	Non Fuzzified Weight (w_i)
PEG	**0.562**
PB	**0.111**
DE	**0.225**
DY	**0.102**

Source: Own calculation

4. 3. CONSISTENCY CHECK

In this step we are able to check the whether the calculated values are usable or not. For this we have to take the same pair-wise comparison matrix which is not normalized as shown in Table 15.

Table 15. Pair-wise comparison matrix in decimal form

Criteria	PEG	PB	DE	DY
PEG	1		4	7
PB	0.2	1	0.5	3
DE	0.25	2	1	3
DY	0.14	0.33	0.33	1

Source: Own calculation

Mean Weights can be obtained by taking simple average of the criteria weights of GMM F-AHP and EAM F-AHP value as shown in the Table 16.

Table 16. Mean Criteria Weights

Criteria	Criteria Weights by GMM F-AHP	Criteria Weights by EAM F-AHP	Mean Weights
PEG	0.640	0.562	**0.601**
PB	0.162	0.111	**0.138**
DE	0.169	0.225	**0.197**
DY	0.028	0.102	**0.065**

Source: Own calculation

Next step is to the multiplication of weights in each respective column as shown in Table 17.

Table 17. Pair-wise comparison matrix after multiplied by weights

Criteria Weights	0.601	0.138	0.197	0.065
Criteria	PEG	PB	DE	DY
PEG	1*0.601	*0.138	4*0.197	7*0.065
PB	0.2*0.601	1*0.138	0.5*0.197	3*0.065
DE	0.25*0.601	2*0.138	1*0.197	3*0.065
DY	0.14*0.601	0.33*0.138	0.33*0.197	1*0.065

Source: Own calculation

In this step of Table 18 we have to calculate the ratio of Weighted Sum Values (WSV) and Criteria Weights (CW).

Table 18. Calculation of the ratio of WSW & CW

Criteria	PEG	PB	DE	DY	Weighted Sum Values (WSV)	Criteria Weights (CW)	$\frac{WSV}{CW}$
PEG	0.601	0.682	0.783	0.447	2.517	0.601	$\frac{2.517}{0.601} = 4.168$
PB	0.121	0.138	0.098	0.192	0.547	0.138	$\frac{0.547}{0.138} = 4.007$
DE	0.151	0.273	0.197	0.192	0.812	0.197	$\frac{0.812}{0.197} = 4.144$
DY	0.084	0.045	0.065	0.065	0.258	0.065	$\frac{0.258}{0.065} = 4.038$

Source: Own calculation

0.601+0.682+0.783+0.447=2.517& so on

Using Equation (18),

Using Equation (19), Consistency Index (C.I) = , where n is the number of compared elements. In this case n = 4 as we have 4 criteria.

Using Equation (19), Consistency Ratio =

We took the value of RI is equal to 0.90 for 4 criteria as shown in Table 19.

Here 0.10 is the standard value as AHP allows up to 10% inconsistency. If the inconsistency is more than 10%, then matrix needs to be reconsidered.

Table 19. Random Index Table up to 10 Criteria

Number of Criteria	1	2	3	4	5	6	7	8	9	10
Value of RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Source: (Saaty, 1980)

We can assume that the matrix is reasonably consistent. So we make continue with the process of decision making using AHP.

Table 20. Percentage of importance of Criteria Weights

Criteria	Criteria Weights	% of Importance (Rounded off)
PEG (Price Earning to Growth)	0.601	**60%**
PB (Price to Book Value)	0.138	**14%**
DE (Debt Equity Ratio)	0.197	**20%**
DY (Dividend Yield)	0.065	**6%**

Source: Own calculation

This percentage of criteria weights according to the importance as shown in the Table 20 can be used by the decision maker for their further investment decision making in the future.

5. FINDINGS

The result shows that

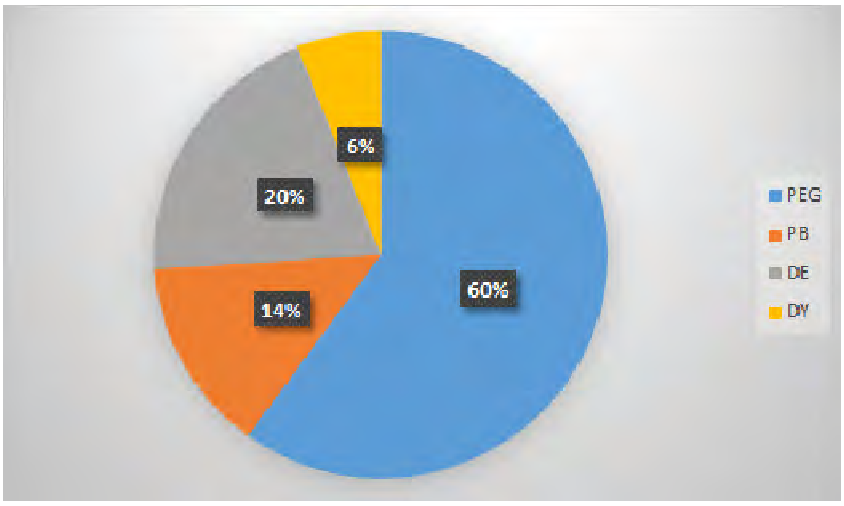
(i) The Price Earning to Growth (PEG) which carries maximum 60% weightage is the most important financial indices for investment point of view.

(ii) The second most important financial Index is Debt Equity Ratio with 20% weightage.

(iii) Price to Book Value and Dividend Yield has 14% and 6% of weightage respectively.

Priority percentage of criteria are represented in Figure 4.

Figure 4. Priority percentage of criteria



Source: Own creation

6. CONCLUSIONS

Based on our comprehensive study, it is evident that the Price Earning to Growth (PEG) ratio, allocated with the highest weightage of 60%, stands out as the most crucial financial index from an investment perspective. This indicates that investors should place significant emphasis for earnings. Following is the Debt Equity Ratio, holding a substantial 20% weightage. This signifies the importance of assessing a company's financial leverage and its ability to meet its financial obligations. A lower Debt Equity Ratio is generally considered more favourable as it suggests a lower level of financial risk. Price to Book Value, with a weightage of 14%, is the third most influential financial index in our analysis. This ratio is indicative of the market's valuation of a company in relation to its book value, providing insights into the underlying assets and liabilities. Finally, Dividend Yield, though not as heavily weighted, still holds significance with a 6% weightage. This metric provides valuable information to income-seeking investors, highlighting the return on investment through dividend pay-outs.

This study emphasizes the paramount importance of considering the Price Earning to Growth (PEG) ratio when making investment decisions, followed by the Debt Equity Ratio. Price to Book Value and Dividend Yield, while relevant, carry comparatively less weightage in the overall assessment. Investors are advised to use these insights as a guideline in their financial analysis and decision-making processes.

6. 1. LIMITATIONS

This study is

- Limited to four financial indices or ratios only.
- Bounded with six financial advisors only.
- Restricted to Triangular Fuzzy Numbers (TFN) only.
- Used a specific MCDM technique i.e. AHP technique.

6. 2. FUTURE SCOPES

The Study

- Has considered four financial indices only, other indices can be taken for analysis in future.
- Is bounded with six financial advisors only. The number financial advisors can be increased to get more precise result in future.
- Can be carried out using pentagonal fuzzy numbers, Hexagonal fuzzy numbers, Pythagorean fuzzy numbers etc.
- Has used one of the methods of MCDM technique for weightage calculations i.e. AHP, further work can be done using DEMATEL.

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ECONOMICS
Innovative and Economics Research Journal
Volume 12, No. 1, 2024
www.economicsrs.com

MARKET SYNCHRONICITY AMONG AFRICAN MARKETS: IS IFRS ADOPTION AN AUGMENTOR OR INHIBITOR?

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Received 29.1.2024. | Sent to review 08.02.2024. | Accepted 11.04.2024.

Original article

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JEL Classification: C3; G1; G3

Doi: 10.2478/eoik-2024-0006

UDK: 336.146:657.2]:658.8(6)

ABSTRACT

This paper investigates the dynamics of market synchronicity and International Financial Reporting Standards (IFRS) adoption in Africa. It seeks to determine whether or not IFRS is an augmentor or inhibitor of market synchronicity in Africa. This study is not only a foundational study that unfolds the dynamics of market synchronicity and IFRS adoption in Africa but also extends the scope of synchronicity from firm-level assessment to country-level market synchronicity. It is one of the few studies which have shifted the literature on synchronicity from one largely limited to firm-level synchronicity to country-level synchronicity through analyses of cross-border market synchronisation. It employs Dynamic Ordinary Least Square (DOLS) and Generalised Method of Moments (GMM) to investigate the market synchronicity-IFRS nexus. The study uses monthly data from March 2005 to November 2021 in five African markets: Botswana, Ghana, Namibia, Nigeria, and South Africa generating 1005 observations in an 18-year data span. The paper reveals a significant negative consequence of IFRS on market synchronicity. Thus, IFRS exhibits an inhibition role in market synchronicity (reduces synchronicity) and improves price informativeness. A decreasing pattern was also observed immediately after IFRS was adopted by the stock markets and persisted for about five years. It implies that the price informativeness of stock markets through IFRS makes them good candidates for intra-Africa portfolio diversification due to reduced investors' risk exposure to market synchronicity.

Keywords: *Market synchronicity, International Financial Reporting Standards (IFRS), Market-wide synchronicity, firm-level synchronicity, Dynamic Ordinary Least Square (DOLS), Generalised Method of Moments (GMM)*

1. INTRODUCTION

International Financial Reporting Standard (IFRS) has emerged as a global accounting standard with widespread acceptance. Even though some countries are still skeptical about IFRS (Jiraskova, & Molin, 2015; Prochazka, 2014), the adoption of IFRS is in ascendency globally (Queku, 2017, 2018). Some have argued that the growing acceptance of IFRS is based on the prior expectation that its adoption could improve financial reporting quality and ensure global uniformity of reporting (Ball, 2016; Tawiah, 2019). It is on this basis that IFRS has received endorsement from international bodies such as the World Bank and the International Monetary

Fund (IMF) with persistent recommendations to developing economies (Queku, 2020).

Despite the continuous recommendation from the World Bank and the IMF to developing economies including Africa to adopt IFRS, the majority of African countries have not adopted IFRS (Gordon, Loeb, & Zhu, 2012; Tawiah, 2019). This is surprising given the fact that more than 65% of countries worldwide have either adopted IFRS or converged, however, only 38.9% (i.e. 21 out of 54) of countries in Africa have fully or partially adopted IFRS (Tawiah, 2019). Some studies have shown that the few countries that have adopted IFRS are yet to harness the expected IFRS benefits (Nnadi & Soobaroyen, 2015; Wieczynska, 2016). It has been argued that the benefits of IFRS adoption are more pronounced in stock market-based economies (Emudainohwo, 2020; Klibi, & Kossentini, 2014). Due to this touted benefit of IFRS, countries that have adopted IFRS but do not have a stock market are increasingly developing their stock markets (Okoye, Okoye, & Ezejiofor, 2014).

Since the benefits of IFRS are maximised within the stock market settings, the existence of the stock market serves as a benchmark for IFRS evaluation to determine the expected benefits. Although several studies have observed the consequences of IFRS on stock markets including information deepening and quality, market liquidity, and increasing trading volume (Kim & Shi, 2012; Leuz & Verrecchia, 2000; Patro & Gupta, 2014), most of these studies are outside Africa with African case still in the infancy (Emudainohwo, 2020). This makes it empirically difficult to interrogate the benefits of IFRS for African markets. African countries generally have high information asymmetry (Queku, Gyedu, & Carsamer, 2020) which has affected investment and development of capital markets in the continent. Given the transparency and disclosure quality of IFRS-based financial reports (Hutton, Marcus, & Tehranian, 2009; Wang, & Yu, 2015), theoretically, it is expected that IFRS would drive the stock markets through the flow of information. However, it has been documented in the literature that causality cannot be inferred (Akitoby et al., 2020). The only scientific basis for affirming or disaffirming these assertions of IFRS in Africa is through empirical investigation.

This study, therefore, follows some of the emerging studies in Africa (Emudainohwo, 2020; Okoye, Okoye, & Ezejiofor, 2014) to assess the benefits of IFRS in Africa using the stock market as a benchmark. This study however differs from the earlier African studies by shifting the focus to the stock market synchronicity-IFRS adoption nexus. Focusing on synchronicity is critical as it has a strong link with stock market development and stability (Patro & Gupta, 2016). Market synchronicity explains the behaviour of a stock market in response to firm-specific information (Roll, 1998; Rosmianingrum, Mohammed, Bujang & Leo, 2023). It is important to note that while market synchronicity has received extensive attention in the literature, whether a higher R-square (i.e. high market synchronicity) demonstrates higher or lower price informativeness remains a point of debate (Chan, & Chan, 2014).

Nevertheless, this study follows studies that argue that the market exhibits a higher stock return synchronicity (i.e. higher R-square) because prices do not incorporate high firm-specific information (Durnev, Morck, & Yeung, 2004; Morck, Yeung, & Yu, 2000; Rosmianingrum, et al., 2023; Wurgler, 2000). Therefore, markets with higher R-square (high market synchronicity) are less price informative. As advanced in Roll (1998), investors may make investment decisions by relying on both firm-specific and market-wide information. It is argued that when a stock price is better explained by market-wide information rather than firm-specific information, there will be evidence of higher synchronicity with the market index or return while less synchronicity will be shown with market-wide information when a stock price is more adequately explained by firm-specific information (Durnev, et al., 2004; Morck et al., 2000; Rosmianingrum, et al., 2023). Accordingly, higher price informativeness and lower synchronicity are used interchangeably.

A lower level of market synchronicity is crucial for forecasting the stock market and share returns and ultimately could deepen stock market activity. Moreover, the synchronicity could drive stock price from the original value which could also have a negative effect on the stock market (Bruno, Sirlei, & Fabiano, 2017; Patro & Gupta, 2016) and may expose investors to greater risk when the price synchronicity increases. Stock market synchronicity is therefore important for actors of stock markets including arbitrage traders, noise traders, analysts, and market regulators.

Following the assertion that IFRS adoption increases disclosures, and improves the quality of disclosure and reporting transparency, the stock price of adopters would become more informative and consequently help investors to collect and trade according to stock information. It would therefore be interesting to know if IFRS adoption in Africa has improved the individual stock market's ability to provide useful information. Given these assumptions, this study, therefore, predicts that IFRS adoption in Africa would decrease stock market synchronicity and improve the flow of market information (Patro & Gupta, 2016). This becomes one of the foundational studies in Africa to assess IFRS as either a stock market synchronicity augmentor or inhibitor. The paper seeks to determine whether or not the adoption of IFRS by African countries improves the information environment and speeds up the capitalisation of individual market price information into prices and consequently reduces synchronicity. This study would contribute to the literature from several folds.

First, the study contributes to the body of literature on market synchronicity by providing evidence that evaluates the instructive explanation of low synchronicity and price-informative complementarity. Moreover, although studies on market synchronicity have been extensive, the predictive value of IFRS in market synchronicity literature is limited (Patro & Gupta, 2016; Rosmianingrum, et al., 2023; Shin, 2019), especially in African settings. The findings would provide useful insights to market regulators for improving the information environment through IFRS compliance.

Secondly, unlike the existing studies which have often focused on firm-level price synchronicity (Bruno, et al., 2017; Patro & Gupta, 2016), this study specifically contributes to the assessment of country-level market synchronicity. Technically, market synchronicity is measured at a firm-level price in relation to the market. Therefore, the assessment of country-level market synchronicity is not common. However, country-level synchronicity is very relevant. Investors do not only rely on firm-level factors but also on market-wide or country-level informativeness for investment decisions (Hasan et al. 2014; Jin & Myers, 2006; Kyiu, 2019; Patro & Gupta, 2016). This paper follows the literature to extend the synchronicity literature by analysing how individual markets in Africa synchronise with or respond to the movement of African market information or market index rather than country-specific information of the firms and the role of IFRS in the synchronisation. The evidence would also have implications on spillover market performance and development.

Thirdly, by linking IFRS to market synchronicity, other African countries that are considering the adoption of IFRS for market economy reasons would have the basis to make an informed decision for either or not to switch to IFRS from their national accounting standards. This may also deepen the discussion of the convergence of global accounting standards and consequently benefit investors who are interested in cross-border listings and stock investments on capital markets. This approach would not only present new insight into the dynamics of the IFRS-synchronicity nexus but also provide comprehensive evidence to evaluate the benefit of IFRS adoption on entire stock markets in Africa.

1. 1. COUNTRY-LEVEL MARKET SYNCHRONICITY: AUGMENTOR VERSUS INHIBITOR

Stock market synchronicity is emerging as an important research area in accounting, finance, and economics literature. Market synchronicity measures how market-wide and firm-specific information influences stock prices and has been the subject of investigation in several prior empirical studies (Bissessur & Hodgson, 2012; Bruno, et al., 2017; Kim & Shi, 2012; Loureiro & Taboada, 2012; Patro & Gupta, 2016). The literature suggests that market synchronicity is driven mainly by two factors: market-wide factors and factors that are idiosyncratic to firms (Kyiu, 2019; Morck, Yeung, & Yu, 2000). According to Kyiu (2019), the market-wide effect shows the extent to which stock prices respond to movements or variations in the overall market index. Kyiu (2019) further explained that the firm-specific effect shows how individual firms' stock prices respond to firm-specific information.

Despite the conclusiveness about what constitutes market synchronicity, there seem to be varying positions about the direction of the relationship between market synchronicity and market informativeness. Some believe that higher synchronicity reflects high market informativeness suggesting a positive relationship (Chan et al. 2013; Piotroski & Roulstone, 2004). Others argue that high synchronicity connotes low market informativeness and vice-versa (Durnev et al. 2003). The differences in the expected direction (positive or negative) of the relationship between market synchronicity and market informativeness may be attributed to the measurement of synchronicity. When the measurement of synchronicity reflects the ratio of the number of times stock prices move together in the same direction to the total number of movements, then, the higher the synchronicity, the higher market informativeness. However, when this traditional view is set aside and synchronicity is measured as the variation of stock returns in relation to the market, then, higher synchronicity leads to lower market informativeness as this suggests that most variations in stock returns on the market are driven or influenced by overall market returns.

This paper follows the latter approach and therefore argues that a higher synchronicity score connotes lower market informativeness. The implication is that factors that increase synchronicity are augmentors and those which restrict or reduce synchronicity are operationalised as inhibitors in this study. Since the stock markets rely strongly on financial information, the informativeness of IFRS and its disclosure quality (Beuselinck, et al., 2010; Kim & Shi, 2012; Loureiro & Taboada, 2012; Queku, 2018, 2017) is expected to translate into market informativeness and hence reducing market synchronicity. Given these fundamentals of IFRS, this paper projects IFRS as an 'Inhibitor' to high market synchronicity.

Studying the complementarity of market synchronicity and IFRS adoption is very critical as these phenomena have become foundational for stock market development. Investigating the stock market synchronicity-IFRS adoption nexus is also relevant due to a strong association between these factors and stock market stability. One further motivation for investigating market synchronicity and IFRS adoption nexus in Africa follows the argument that emerging and developing markets such as African markets exhibit higher market synchronicity than developed markets (Beuselinck et al, 2010). Some of the cited reasons for developing markets such as African markets to exhibit higher market synchronicity levels than developed markets include poor quality of information and disclosures, poor governance, and law enforcement/protection of investors' rights which turn to discourage trading leading to slower incorporation of information into market prices (Bissessur & Hodgson, 2012; Morck et al. 2000). Despite this assertion, there is a paucity of literature providing comprehensive evidence about whether or not African markets are synchronous. With the adoption of IFRS by some African markets, would the narrative change as it is believed that the IFRS adoption could improve market informativeness and thereby speed up the flow of information.

Technically, market synchronicity is measured at a firm-level price in relation to the market. Therefore, the assessment of country-level market synchronicity is not common. However, country-level synchronicity is very relevant. Investors do not only rely on firm-level factors but also market-wide or country-level informativeness for investment decisions (Hasan et al. 2014; Jin & Myers, 2006; Kyiu, 2019). Recognising the relevance of country-level synchronicity, Patro and Gupta (2016) proposed a measurement for country-level synchronicity. According to Patro and Gupta (2016), country-level synchronicity may be measured as the simple average of firm-level synchronicity. This paper, however, measures country-level or market-wide synchronicity as the extent to which individual stock market responds to movements or variations in the overall African market index. This measurement and the analytical procedures therefrom would provide evidence about the co-movement of African markets over time and the extent to which individual markets absorb African-based market information.

2. THEORETICAL UNDERPINNINGS

The efficient market hypothesis and information asymmetry are widely cited theories in the study of stock markets and information flow. The traditional view of the efficient market hypothesis (EMH) is that a stock market is efficient when its stock price fully reflects the available information (Kyiu, 2019; Queku & Carsamer, 2016). This implies that investors cannot rely on past and current information to outperform the market or earn above the market return. Traditionally, this assumption holds when some foundational conditions exist: there is no cost to information; no transactional cost in the trading; and agreement exists among all investors in respect of current information impact on both current and future prices (Ball, 1996; Fama, 1970). Following these assumptions, when the extra cost is incurred to improve information flow, the market would still not be considered as efficient. Thus, although IFRS is believed to improve information disclosures and quality (Queku, 2020), since the adoption comes with a cost, the market would still not be considered as efficient.

Given the practical difficulties associated with the traditional view of what constitutes an efficient market, Fama (1970) asserts that although the foundational conditions are sufficient, they are not necessary as they are not typical of markets in practice. It has therefore been argued that a market could still be considered efficient even when there is a transaction cost so long as the marginal benefit and marginal cost of using and acting on the available information are equal (Jensen 1978). Following this development, one can argue theoretically that price informativeness associated with IFRS adoption could enhance market efficiency.

In contributing to EMH, Ball (1996) has drawn a very interesting dimension of the cost analysis of information and market efficiency. According to Ball (1996), information asymmetry and market inefficiency may emerge not only because of the cost of information but also the cost of processing the information. Thus, even if there is no information cost, there is still a cost for interpreting the information. However, the existence of information processing or interpretation costs does not make a market inefficient but the extent of the cost vis-à-vis the benefits thereafter. This implies that a market can be considered efficient when the cost investors would incur to process or interpret the available information is significantly less than the benefits of that information.

Financial information remains a fundamental source of information for investment decisions, therefore, the extent of disclosures and quality of disclosures may be associated with the expected cost of interpretation and processing. IFRS-based information follows full disclosure with high informational quality (Beuselinck, Joos, Khurana, & Vander Meulen, 2010; Kim & Shi, 2012; Loureiro & Taboada, 2012; Queku, 2020; 2018, 2017) which would minimise the interpretation and subsequently improve market informativeness. Thus, following the current understanding of the efficient market, when IFRS-based financial reports deepen the quality and quantity of publicly available data on firms' fundamentals and the information environment improves, investors could more accurately predict future events that should reasonably be reflected in the country-level firms' stock prices. This could make prices reflect higher country-level price information (i.e. higher price informativeness) than African-wide market information resulting in lower R-square (i.e. lower market synchronicity) (Durnev, et al., 2004; Morck, et al., 2000; Rosmianingrum, et al., 2023; Wurgler, 2000). Thus, higher country-level price informativeness through IFRS could lower market synchronicity. Theoretically, there is therefore a possible connection between IFRS adoption and market synchronicity.

2. 1. EMPIRICAL LITERATURE, LESSONS LEARNT, AND HYPOTHESIS DEVELOPMENT

The theoretical literature provides transmission mechanisms connecting IFRS and market synchronicity. However, whether the benefit of IFRS-induced information adequately compensates for the interpretation cost (whether minimal or not) would be an empirical question (Patro & Gupta, 2016). The empirical investigation is very critical to trim the understanding of IFRS's role in market informativeness. The study of Beuselinck, Joos, Khurana, & Vander Meulen (2010) investigated the impact of IFRS mandatory adoption on price informativeness using data from 14 EU countries. Beuselinck, et al., (2010) found a decrease in stock price synchronicity after IFRS adoption, however, the synchronicity increased subsequently. Moreover, using data from 34 countries, Kim and Shi (2012) demonstrated that the price synchronicity of the markets has decreased following IFRS voluntary adoption. Kim and Shi (2012) further revealed that the synchronicity is lower for firms that have adopted IFRS when compared to those which have not yet adopted IFRS. Loureiro and Taboada (2012) also showed that IFRS adoption contribution to improved stock price informativeness is considered more significant for firms that voluntarily adopted IFRS than mandatory IFRS adopters.

Even though some empirical evidence suggests that price informativeness is associated with IFRS adoption (Beuselinck et al., 2010; Bissessur & Hodgson, 2012; Dasgupta, Gan, & Gao, 2010; Patro & Gupta, 2016; Kim & Shi, 2012; Loureiro & Taboada, 2012), stock market-based cross-country analyses have been inconclusive (see Kyiu, 2019; Patro & Gupta, 2016). Patro and Gupta (2016) revealed that IFRS adoption has improved the information environment of all the four markets used in their study: China, Hong Kong, Israel, and the Philippines reducing stock price synchronicity. However, using the markets of Nigeria and South Africa, Kyiu (2019) showed that IFRS adoption has not led to significant improvement in informativeness in earnings, a key parameter for market price determinant. Kyiu (2019)'s study is one of the emerging studies in Africa. Kyiu (2019) however did not connect IFRS adoption to price synchronicity rather it was linked to earning informativeness. Thus, evidence of IFRS adoption and synchronicity is virtually absent in African literature even though several countries in Africa are taking steps to regularise their accounting standards to IFRS to improve financial reporting informativeness and as preparation for a shift from bank-based economies to stock market economies.

A critical consideration of the empirical studies shows that almost all the existing studies of price synchronicity have focused on firm-level price synchronicity (Bissessur & Hodgson, 2012; Bruno, et al., 2017; Kim & Shi, 2012; Loureiro & Taboada, 2012; Patro & Gupta, 2016). However, investors do not only rely on firm-level factors but also market-wide informativeness for investment decisions. It is therefore not surprising that some emerging studies have operationalised synchronicity into firm-level and market-wide synchronicity (Hasan et al. 2014; Jin & Myers, 2006; Kyiu, 2019). Following Morck, Yeung, and Yu, (2000), this study extends the synchronicity literature by analysing how individual markets in Africa synchronise with or respond to the movement of African market information or market index. The study would provide evidence about the existence of co-movement of African markets over time and the extent to which individual markets absorb African-based market information. The evidence would also have implications on spillover market performance and development.

Despite the differences in prior research efforts and the current study, the literature seems to suggest that IFRS adoption would lead to a synchronicity-reducing effect. This implies IFRS adoption could speed up the flow of firm-specific information to stock prices reducing market synchronicity (i.e. reducing investors' reliance on market-wide information). Consolidating these empirical lessons (Beuselinck et al., 2010; Bissessur & Hodgson, 2012; Bruno, et al., 2017; Kim & Shi, 2012; Loureiro & Taboada, 2012; Patro & Gupta, 2016) with the theoretical lessons from IFRS informativeness and EMH, this paper posits that IFRS adoption is market synchronicity inhibitor rather than augmentor or enhancer. Moreover, while several of the local accounting standards often focus on the informational needs of the government with little relevance to investors (Bruno, et al, 2017; Lopes, 2006), IFRS-based financial reports are expected to increase both the quantity and the quality of financial informational content relevant to current and prospective investors in the markets of adopters' country (Beuselinck et al, 2010; Bissessur & Hodgson, 2012; Bruno, et al, 2017; Patro & Gupta, 2016) and therefore improves country-level price informativeness and inhibits market synchronicity. The paper, therefore, presents its hypothesis in its working hypothesis form as follows:

H_0: IFRS adoption significantly reduces market synchronicity in Africa

3. ESTIMATION FRAMEWORK

This paper investigates how IFRS adoption could augment or inhibit market synchronicity in African markets. The study operationalises market synchronicity as the dependent or response variable while IFRS adoption is the independent variable. Country-specific variables relevant to market synchronicity are used as control variables. To estimate market synchronicity and IFRS adoption nexus, this paper follows the panel model specifications as the investigations involve data from each stock market (cross-section), 'i' over the longitudinal period 't'. The combination of both cross-sectional data and time series data in the same investigation makes the use of panel model specification suitable. The panel model also controls the heterogeneity effect (Seidu, Queku & Carsamer, 2021). The paper also conducts some pre-diagnostics relevant to the data. These include multicollinearity problem checks and data properties. The empirical specification follows Bruno et al (2017) which estimates the variables of interest with control variables and it is specified generally as:

$$Y_{it} = \alpha_0 + \sum_{j=n}^{k} \beta_j X_{it} + \sum_{k=i}^{z} \theta_p C_{it} + \varepsilon_{it} \quad (1)$$

Where:

Y is the dependent or response variable. It denotes market synchronicity of the individual markets

X is the IFRS and it forms the independent variable

C as the vector of the control variables

'i' denotes individual market-level observations

't' denotes the time

B_j is the coefficient of the independent variables (IFRS variables)

θp is the vector of coefficients of the control variables

α is the constant of the model or the intercept

ε is the error term

3. 1. DATA AND MEASUREMENT OF VARIABLES

The study involves stock markets in Africa. Consistent with the existing literature, this paper considers African markets which have fully adopted IFRS (De Simone, 2016; Okafor et al, 2019). The full IFRS adopters (IFRS) are countries where firms use only IFRS and IFRS for Small and Medium Enterprises ($IFRS_{sme}$). Thus, the selection criteria are as follows: first, the country selected must have a stock market. Secondly, the country does not have any alternative financial reporting standard other than IFRS and IFRS for Small and Medium Enterprises ($IFRS_{sme}$). This would help determine the true effect of IFRS. Thirdly, early adopters are excluded. The paper operationalises early adopters as countries that adopted IFRS before 2005 (Tawiah, 2019). According to Queku et al., (2022), the early adopters do not have sufficient pre-IFRS data for comparative analysis. Finally, the market has been in operation since 2005. This would capture enough data for both pre and post-IFRS periods.

Applying these selection criteria, five (5) countries/markets have been selected for the investigation. The data set for the investigation consists of monthly stock indexes for five countries: Botswana, Ghana, Namibia, Nigeria, and South Africa. Although financial reports are published annually, the benchmark analysis can be conducted at frequent intervals such as even weekly (Fernandes & Ferreira, 2008; Loureiro & Taboada, 2012). The stock indices are collected from EquityRt and the database of the individual stock markets. The data range from March 2005 to November 2021, yielding 1005 observations. This data range is chosen because it is the range where most of the target markets/countries have sufficient data for both pre and post-IFRS periods.

There are three categories of variables in this paper: dependent variable, independent variable, and control variables. The two variables of interest are market synchronicity which is the dependent or response variable and IFRS adoption which is the independent variable. The paper follows the existing literature to control for regulatory control (RC), rule of law (ROL), voice, and accountability (VAA) and sto,ck market development (SMD) (Akalpler, 2020; Bissessur and Hodgson, 2012; Gul, Kim, and Qiu, 2010; Jin & Myers, 2006; Khandaker, 2011; Landsman, Maydew, & Thornock, 2012; Morck et al. 2000). The measurement of these variables is as follows:

3. 1. 1. MARKET SYNCHRONICITY

This paper measures synchronicity from the R-square proxy. This is viewed as the main measure of synchronicity and it is widely used (Bruno, et al, 2017; Chan & Hameed 2006; Kyiu, 2019; Morck et al. 2000, Patro & Gupta, 2016). This makes it appropriate and consistent with the existing literature. Traditionally, synchronicity has been firm-level analysis, however, according to Patro and Gupta (2016), market synchronicity can be extended to the country level by averaging the firm-level scores. This paper though focuses on country-level (market-level) synchronicity; it uses an alternative approach to the suggestion by Patro and Gupta (2016). Since the paper seeks to explore market synchronicity in Africa, it would follow the R-square measure as usual but uses the African market index as the reference point and individual market index as the baseline. This measure would show the extent to which market price reflects market-specific information and African market information. Thus, 1-R^2 will show the variation in stock price which is explained by individual market-specific information. The paper thus follows Morck et al. 2000's R-Square measure and applies as follows:

i. Collect data on market indices of each of the markets in the sample frame
ii. Collect data on the African market index
iii. Regress market-specific index on African market index as formulated in Eqn (2)
iv. Unlike studies such as Piotroski and Roulstone (2004) where industry indices are included in Eqn (2), this paper would not include industry indices since the study uses country-level data. Moreover, as argued by Chan and Hameed (2006), incorporating industry indices is problematic, especially for developing and emerging markets as markets within this category are often dominated by relatively few industries and thus it is difficult to disentangle industry-effect from market-effect. Furthermore, it is argued that an industry-based return is more likely to reflect or convey firm-specific information than the expected industry-based information especially when there are relatively few firms in a particular industry
v. The resulting R-Square is substituted in Eqn (2)

$$RMK_{it} = \delta_{it} + \beta_i AMR_t + \varepsilon_{it} \tag{2}$$

Where:

RMK is the market-specific return of market 'i' in period 't'

AMR is the African Market Return in period 't'

A higher R^2 in Eqn (2) implies higher synchronicity and lower market informativeness of the individual markets in Africa.

3. 1. 2. IFRS ADOPTION

IFRS adoption is the independent variable. This paper follows the existing literature to measure IFRS adoption through a binary score where 1 is assigned in the period of IFRS adoption, otherwise (Braga, 2017; De Simone, 2016; Prato & Gupta, 2016; Queku et al., 2022; Rosmianingrum, et al., 2023).

3. 1. 3. CONTROL VARIABLES

Some studies have cited that market synchronicity is driven by factors such as rule of law (ROL), voice and accountability (VAA), regulatory control (RC) and stock market development (SMD) (Akalpler 2020; Bissessur and Hodgson, 2012; Gul, Kim, & Qiu, 2010; Jin & Myers, 2006; Gul, Kim, & Qiu, 2010; Khandaker, 2011; Landsman, Maydew, & Thornock, 2012; Morck et al. 2000). Therefore, to investigate the true contribution of IFRS adoption to market synchronicity, the paper controls for these variables: ROL, VAA, RC and SMD. The study follows Kaufmann et al (2009) indices of the Worldwide Governance Indicator database. The measurement is in units with a range of -2.5 to 2.5. A higher value implies a sound and effective ROL, VAA and RC in the country. Market development is measured by market capitalisation. Table 1 presents the summary of these variables and their measurements

Table 1. Summary of Variables, Measurements and Apriori

Variables	Descriptions	Measurements	Apriori
Dependent: Syn	Synchronicity	R-Square	n.a
Independent:			
IFRS	IFRS adoption	Binary	-
Control Variables:			
ROL	Rule of Law	Kaufmann Index	-
VAA	Voice and Accountability	Kaufmann Index	-
RC	Regulatory Control	RC	-
MKD	Market Development	Market Capitalisation	-

Source: Authors' Construct: Developed from Varying Literature

3. 2. ESTIMATION APPROACH

The paper operationalises Eqn(1) by substituting the specific variables of interest and the control as measured and summarised in Table 1. The study estimates the empirical model using the Panel Dynamic Ordinary Least Square (Panel DOLS) approach. The DOLS is capable of handling possible unit root problems from the time series characteristics of the data (Anastasiou, 2016; Seidu, Queku, Tackie & Mensah, 2022). The DOLS estimation approach is still robust even with a small sample size (Queku & Carsamer, 2016; Yi, Heng & Wong, 2009). The leads and lags integrated into the DOLS estimation eliminate simultaneity biases (Queku et al, 2022; Stock & Watson, 1993). The Panel DOLS specification is formulated as:

$$Y_{it} = \delta_0 + \delta_1 X_{it} + \sum_{i=-q}^{p} \pi_i \Delta X_{it-i} + \epsilon_{it} \tag{3}$$

Where:

is the synchronicity

represents the matrix of both the regressors (IFRS variables) and control variables.

the constant or the intercept of the model

and are the cointegrating vectors of a change in X on Y

p and q are the lag and lead length.

is the error term.

The individual variables are substituted into Eqn (3) to formulate the model for the estimation as follows:

$$Syn_{it} = \delta_0 + \delta_1 IFRS_{it} + \delta_2 ROL_{it} + \delta_3 VAA_{it} + \delta_4 RC_{it} + \delta_5 MKD_{it} + \sum_{i=-q}^{p} \pi_1 \Delta IFRS_{it-i} + \sum_{i=-q}^{p} \pi_2 \Delta ROL_{it-i} + \sum_{i=-q}^{p} \pi_3 \Delta VAA_{it-i} + \sum_{i=-q}^{p} \pi_4 \Delta RC_{it-i} + \sum_{i=-q}^{p} \pi_5 \Delta MKD_{it-i} + \epsilon_t \tag{4}$$

Where:

It is expected that the coefficients of IFRS, ROL, VAA, RC and MKD <0

The rest of the variables remain as described under Eqn (3) and Table 1

3. 3. ROBUSTNESS CHECK

The paper further conducts a robustness check using the Generalised Method of Moment (GMM). This benchmark estimation approach is used to determine consistency in the estimates. The GMM system specifications incorporate instrumental variables to control for the unobserved heterogeneity and account for endogeneity (Carsamer, Abbam & Queku, 2021; Queku, 2017; Seidu, et al., 2021). The GMM estimation approach also accounts for cross-sectional dependence and reduces over-identification (Doyle, 2017; Roodman, 2009; Seidu et al, 2021). It is capable to handle and analyse unknown parameters which are not captured in the sample moments making the results and estimates quite robust (Queku, 2017; Zhohar, 2012). Similar to DOLS, it is able to handle a small sample size. The model is specified with lagged dependent as follows:

$$Y_{it} = \theta Y_{it-1} + \sum_{m=i}^{M} \varphi_m X_{it} + \sum_{n=i}^{N} \omega_n D_{it} + \mu_i + \varepsilon_{it} \tag{5}$$

Where:

Y_{it} is the synchronicity

Subscripts i denotes the individual markets/country (cross-sectional dimension) and t represents the time dimension of the panel model

Y_{it-1} represents the initial level of the synchronicity

X_{it} and D_{it} are the kx1 vectors of the explanatory variables representing IFRS and control variables respectively

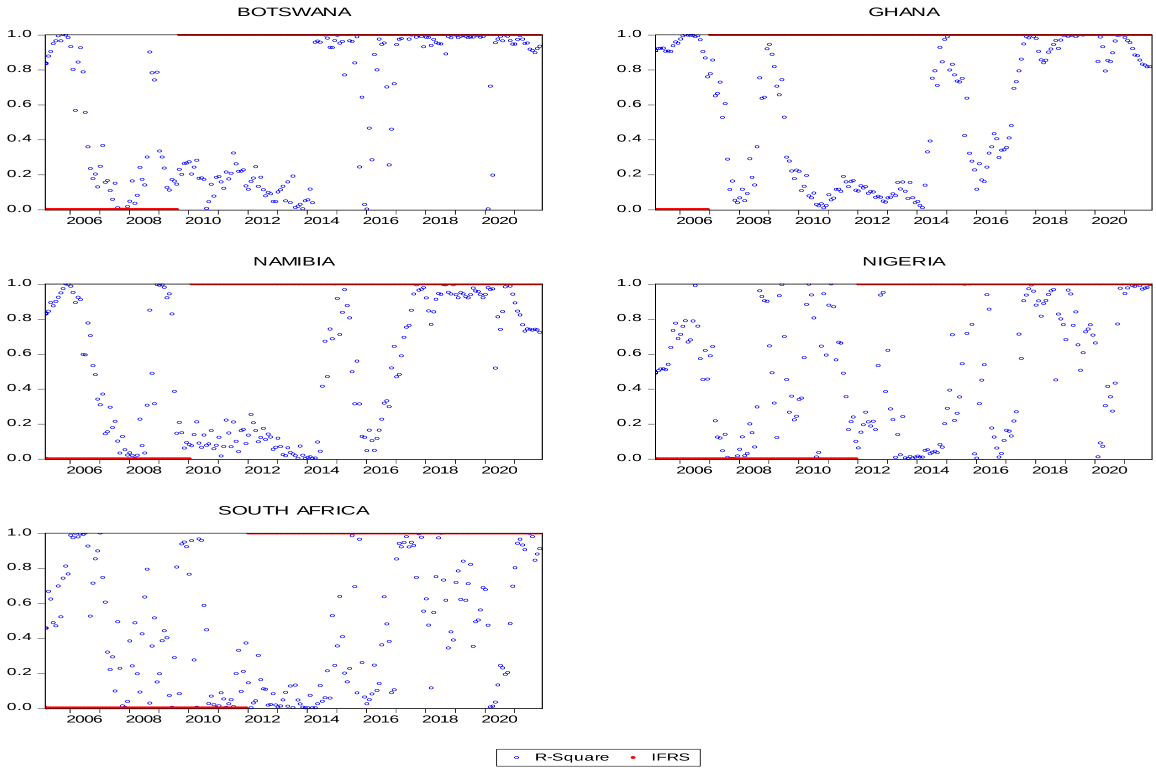
μ_i are the unobserved heterogeneity such as market or country-specific effects

is the usual error term.

4. TREND ANALYSES OF MARKET SYNCHRONICITY AND IFRS

Figure 1 presents the dot plots of the trend in market synchronicity and IFRS at the country level. It can be observed that generally, market synchronicity is lower in post-IFRS periods than the pre-IFRS periods. Figure 1 further reveals that in all the stock markets, market synchronicity is lowest in the early periods of adoption (i.e. relatively within 5 years of IFRS adoption). Specifically, it can be seen from Figure 1 that the market synchronicity of all the stock markets exhibited a sudden decreasing pattern immediately after IFRS adoption and sustained such a trend for a relatively long period (average of five years). For instance, see the decreasing pattern of 2009-2014; 2007-2009; 2010-2014; 2012-2015; and 2012-2015 for Botswana, Ghana, Namibia, Nigeria and South Africa respectively. This is consistent with the evidence in some developing and emerging markets (see Beuselinck, et al., 2010; Figlioli, Lemes & Lima, 2017; Patro & Gupta, 2016). The persistence of the decreasing trend began to change after an average of five years. This also corroborates the conclusions drawn by Beuselinck, et al., (2010) who found a decrease in stock price synchronicity after IFRS adoption, however, the synchronicity increased subsequently. This may suggest that the markets turn to develop resistance to the persistence in the increasing trend of informativeness through IFRS requirements with time. Weaknesses in the regulatory framework and enforcement of IFRS compliance might have also played role in the subsequent reversal of the downward trend.

Figure 1. Dot Plot of Market Synchronicity and IFRS Trend (2005-2021)



Source: Authors' Graph Developed from Eviews 9.0 Package

4. 1. DESCRIPTIVE ANALYSES

The all-sample descriptive statistics of the variables of interest and the vector of controls are presented in Table 2. The mean market synchronicity is 0.5055. This suggests a relatively significant synchronicity of the African market. This shows that individual market prices in the selected markets reflect about 49.45% of country-specific price information and 50.55% of African-wide market information. The mean values for regulatory control (RC) and voice and accountability (VAA) are positive. Rule of law (ROL) is however negative while stock market development (SMD) exhibited relatively high positive mean in relation to the gross domestic product (GDP). The standard deviation of all the variables are relatively high in relation to the mean values suggesting high degree of dispersion. For brevity, the control variables are not discussed. Table 2 further provides normality statistics of the data: Skewness, Kurtosis and Jarque-Bera. Since normality is not a core assumption of panel estimation, the paper does not discuss the results.

Table 2. All Samples Descriptive Statistics (2005-2021)

	R_SQUARE	IFRS	RC	ROL	VAA	SMD
Mean	0.5055	0.7025	0.0251	-0.0421	0.2913	58.2864
Median	0.4876	1.0000	0.0618	0.0724	0.4673	15.5441
Std. Dev.	0.3745	0.4574	0.5184	0.5432	0.4580	94.0387
Skewness	0.0374	-0.8858	-0.5667	-1.0357	-1.4556	1.6814
Kurtosis	1.3370	1.7847	2.3208	2.8359	3.4768	4.1511
Jarque-Bera	116.0397	193.2858	73.11683	180.7909	364.4003	529.0467
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	1005	1005	1005	1005	1005	1005

Source: Authors' Estimation from Eviews 9.0 Package

Table 3 also reports the descriptive statistics of the individual stock market synchronicity. It can be seen that all five markets have enjoyed improved country-specific price informativeness with IFRS adoption as evident in the reduced market synchronicity except Botswana. In absolute terms, except Botswana, all the stock markets have seen improved country-specific price informativeness (IPI) with Ghana being the highest gainer (46%) followed by South Africa (9%), Nigeria(4) and Namibia (3%).

Table 3. Country-Level Descriptive Statistics of Market Synchronicity (2005-2021)

	Pre-IFRS			Post-IFRS			*IPI
	Mean	Median	StdDev	Mean	Median	StdDev	
Botswana	0.4298	0.2429	0.3651	0.6033	0.8960	0.4048	40%
Ghana	0.9395	0.9438	0.0573	0.5053	0.4280	0.3728	46%
Namibia	0.5084	0.4804	0.3780	0.4911	0.4894	0.3816	3%
Nigeria	0.5110	0.4843	0.3160	0.4910	0.4488	0.3729	4%
South Africa	0.4556	0.4320	0.3486	0.4155	0.3509	0.3573	9%

Note: **IPI denotes Improved Market Informativeness (or reduced market synchronicity)*

Represents decrease and increase respectively

Source: Authors' Estimation from Eviews 9.0 Package

4. 2. CORRELATION ANALYSES

The absolute analyses from the dot plot and the descriptive statistics suggest a market synchronicity-IFRS nexus. This paper, therefore, seeks to further conduct inferential analyses through panel specifications to establish the extent of the connectedness. Prior to this analysis, the study checks the correlation coefficients among the independent variables to determine the possibility of a multicollinearity problem that could adversely affect the reliability of the estimates. The results of the correlation matrix are captured in Table 4. The p-value of the coefficients are in the parentheses and the coefficients outside the parentheses. It is important to note that the multicollinearity is based on the magnitude of the absolute coefficients and not the significant level as depicted by the p-values. Table 4 shows that there is no multicollinearity problem as none of the correlation coefficients are above the threshold of 0.9 (Salmeron-Gomez, Garcıa-Garcıa, & Garc´ıa-P´erez, 2020).

Table 4. Correlation Matrix of the Explanatory Variables

Variables	IFRS	RC	ROL	VAA	SMD
IFRS	1.000000				

RC	-0.0611	1.000000			
	(0.0528)	-----			
ROL	0.1375	0.8928	1.000000		
	(0.0000)	(0.0000)	-----		
VAA	0.1783	0.8132	0.8877	1.000000	
	(0.0000)	(0.0000)	(0.0000)	-----	
SMD	-0.0411	0.2622	0.0605	0.3735	1.000000
	(0.1932)	(0.0000)	(0.0551)	(0.0000)	-----

Source: Authors' Estimation from Eviews 9.0 Package

5. EMPIRICAL RESULTS AND DISCUSSIONS

The results of the estimation of the panel models are captured in Table 5. Table 5 has three columns. The first column reports the study variables including the vector of control variables. The estimates from the main estimation strategy: DOLS are reported in the second column while the robustness check as captured by GMM is reported in the third column. In each of the two modeling columns (DOLS and GMM), the study reports two values. The first is the coefficient while the second value inside the parenthesis is t-statistics. The significance level is denoted by *,**, and *** for 10%, 5%, and 1% respectively.

The estimates from the DOLS and GMM are similar. All the indicators are similar in both direction and magnitude. This makes the estimates robust. With respect to the main variable of interest: IFRS, Table 5 shows that it exhibits a negative influence on market synchronicity. Specifically, the coefficient of IFRS is -0.1281. This coefficient is significant at 5%. This suggests that the null hypothesis is rejected and concludes that IFRS adoption reduces market synchronicity and improves country-specific price informativeness. Besides, all the control variables are significant and negative other than market development which shows an insignificant negative effect. Thus, governance structure (i.e. sound regulatory control (RC), rule of law (ROL), and voice and accountability (VAA)) are antecedents of improved country-specific price informativeness. For brevity, these control variables are not discussed in detail.

Table 5. Panel Analyses of Market Synchronicity and IFRS (2005-2021)

Variables	DOLS	GMM
R-Square(-1)		0.8835***(9.7756)
IFRS	-0.1281**(-1.9789)	-0.1377***(-4.5846)
RC	-0.4006*(-1.7523)	-0.3965***(-3.7978)
ROL	-0.4626*(-1.6502)	-0.4589***(-3.6065)
VAA	-0.4626*(1.6502)	-0.1883*(-2.2702)
SMD	-0.0016 (1.1941)	-0.0006(1.4052)
Adjusted R^2	0.5072	-
J-stat		8.52E-25

Source: Authors' Estimation from Eviews 9.0 Package

The paper further conducts country-specific estimation to check the possible changes in the dynamics of the IFRS-synchronicity nexus with the results captured in Table 6. It can be observed that except for Botswana, each of the country-level synchronicity of the stock markets exhibit significant inhibition response from IFRS (i.e. IFRS reduces synchronicity). The inhibition coefficient of IFRS is highest for South Africa (0.1997) and least for Ghana (0.1219) in absolute terms.

Table 6. Disaggregate Analyses of Market Synchronicity and IFRS (2005-2021)

Variables	Botswana	Ghana	Namibia	Nigeria	South Africa
IFRS	0.1820	-0.1219***	-0.1257*	-0.1879**	-0.1997***
RC	0.0343	0.5900***	1.7165***	0.2446	0.4164**
ROL	-3.3822***	-0.0537	-2.0079***	1.7683***	-0.9570***
VAA	0.3779	-0.4696***	0.3123	-0.9321***	3.5850***
SMD	-0.0382	0.0013***	0.0532***	-0.0584***	0.0015*
Adjusted R^2	0.4186	0.6389	0.4697	0.2339	0.3223

Source: Authors' Estimation from Eviews 9.0 Package

The results from all sample analyses (panel) and the country-specific analyses (cross-section) portray the stability of the findings where IFRS exhibits a significant negative influence on market synchronicity (i.e. inhibition effect). This suggests that the adoption of IFRS in Africa has improved country-level price informativeness and reduced market synchronicity. It is therefore concluded that IFRS is an inhibitor of market synchronicity in Africa. The findings are also consistent with the extended assumption of EMH (Ball, 1996). Ball (1996) suggests that low information processing and interpretation costs could make a market efficient. Therefore, the expectation is that since IFRS follows full disclosure with high informational quality (Beuselinck, Joos, Khurana, & Vander Meulen, 2010; Kim & Shi, 2012; Loureiro & Taboada, 2012; Queku, 2018, 2017), it would minimise interpretation cost of investors and traders and subsequently improve the flow of information and price informativeness. Thus, the significant negative relationship between IFRS and market synchronicity affirms Ball (1996)'s extended assumption of EMH.

Besides the theoretical relevance of the findings, evidence in this study also corroborates the earlier evidence in the literature (Figlioli, et al., 2017; Kim & Shi, 2012; Patro & Gupta, 2016; Wang & Yu, 2015). These authors also observed that IFRS adoption improves price informativeness and reduces synchronicity. Additionally, some studies have documented that a decrease in market synchronicity is linked to improved firm- specific informativeness (Kim & Shi, 2012; Patro & Gupta, 2016; Shin, 2019). Comparatively, the findings suggest that IFRS largely inhibits market synchronicity in and across Africa as similar findings have been observed in other regions such as Asia and other emerging markets (Beuselinck, et al., 2010; Bissessur, & Hodgson, 2012; Figlioli, et al., 2017; Patro & Gupta, 2016) even though as observed in Figure 1, the synchronicity could rise subsequently (Beuselinck, et al., 2010; Bissessur, & Hodgson, 2012).

One fundamental implication of the findings is that IFRS-based financial reports speed up the flow of firm-specific information (country-level) into stock prices making firm-specific information better for explaining stock prices than African-wide market information. This has resulted in negative consequences on market synchronicity. The findings also provide evidence that investors believe that firm-specific information (country-level) through IFRS-based financial reports is more valuable and relevant for trading, than African-wide market information making it significantly more impactful on changes in stock price than alternate sources of trading information (market-wide sources).

The evidence of enhanced trust in IFRS-based accounting data could be beneficial to firms that deepen the quantity and quality of accounting information as investors could differentiate them from others and address the popular irrational selection 'lemon market problem (i.e. quality uncertainty problem)'. The findings further provide investors (current and potential investors) with the basis to rely on IFRS-based accounting data to minimise uncertainty and risk exposures in investment decisions through price informativeness. It implies that price informativeness of stock markets through IFRS makes them good candidates for intra-Africa portfolio diversification due to reduced investors' risk exposure to market synchronicity.

Further reason for the inhibition role of IFRS in market synchronicity as found in this study is that IFRS adoption and compliance enhance information and financial transparency through improved financial reporting. This could lead to a reduction in informational asymmetry between firms (managers) and investors (current and potential), improve price informativeness and ultimately reduce market synchronicity. The results also imply that IFRS adoption provides the window for improved firm-specific information flow to reflect in stock prices and investors' expectations about the future cash flow of the stocks. The findings further imply that contrary to the general belief that IFRS has limited benefit for less developed stock markets (Emudainohwo, 2020; Klibi, & Kossentini, 2014; Queku, 2020), the evidence found in this study suggests that emerging and less developed markets such as those in Africa could also benefit from IFRS adoption through price informativeness and undermine overreliance of market-wide information (reduce synchronicity). The evidence in this paper also demonstrates that the nature of accounting standards in use really matters in stock price determination, market synchronicity, and informativeness.

6. CONCLUSION AND IMPLICATIONS

This paper unfolds the dynamics of market synchronicity and IFRS adoption in Africa. The study is conceived on the ground that it is generally believed that African markets have high information asymmetry (high market synchronicity) which has affected investment and development of capital markets in the continent. Given the transparency and disclosure quality of IFRS-based financial reports, theoretically, IFRS is expected to drive the stock markets through the flow of firm-specific price information (country-level). However, there is a paucity of empirical evidence on market synchronicity and IFRS adoption in Africa even though several African countries have adopted IFRS. Moreover, at the global stage, the evidence is limited to firm-level synchronicity rather than market-level synchronicity through cross-border market synchronisation.

This paper extends the literature in the African context and the scope to country-level market synchronicity. The investigation uses monthly data from March 2005 to November 2021 in five African markets: Botswana, Ghana, Namibia, Nigeria, and South Africa generating 1005 observations in an 18-year data span. The paper follows the Dynamic Ordinary Least Square (DOLS) estimation approach validated by the Generalised Method of Moment (GMM).

The primary findings show that the adoption of IFRS in Africa has improved firm-specific price informativeness (country-level) and reduced synchronicity (reduce overreliance on market-wide information). It is concluded that IFRS is an inhibitor of market synchronicity in Africa. The findings imply that the inhibition role of IFRS in market synchronicity as found in this study is that IFRS adoption and compliance enhance information and financial transparency through improved disclosures and reporting quality. This could lead to a reduction in informational asymmetry between firms (managers) and investors (current and potential) and ultimately reduce market synchronicity. Another implication of the findings is that IFRS could reduce investors' risk exposure arising from market synchronicity and ultimately could deepen stock market activity.

The evidence further implies that IFRS-based financial reports speed up the flow of firm-specific information (country-level) into stock prices making firm-specific information better for explaining stock prices than African-wide market information. This has resulted in negative consequence on market synchronicity. The findings also provide evidence that investors believe that firm-specific information (country-level) through IFRS-based financial reports is a more valuable and relevant for trading, than African-wide market information making it significantly more impactful on changes in stock price than alternate sources of trading information (market-wide sources).

Although the inferential analyses show IFRS as a significant inhibitor of market synchronicity, the trend analyses reveal that such a sudden decreasing pattern immediately after IFRS adoption persists for an average of five years. Thereafter, the persistence of the decreasing trend began to change. This may suggest that with time firms within the markets turn to develop resistance to the increasing trend of informativeness through IFRS requirements especially when the disclosures expose the aberrant activities of managers of such firms. Besides, the reverting trend (i.e. reducing to increasing) could be attributable to the laxity in strictly enforcing the IFRS reporting requirements. The policy implication is that regulators of the various markets in Africa should closely monitor the IFRS compliance of firms to ensure financial reporting quality and improved disclosures for sustained informativeness of the market and consequently reduced market synchronicity. Thus, market regulators could use IFRS for improving the information environment.

The reduced market synchronicity through IFRS implies that prices of the individual stock markets in Africa reflect country-level price information (firm price informativeness) rather than African market-wide information making it a disincentive for speculative activity through the use of spillover African-wide market information. The adoption of IFRS by African countries could improve the information environment and speed up the capitalisation of firm-specific price information into prices and consequently reduce synchronicity (over reliance on market-wide information). The practical implication is that price informativeness of stock markets through IFRS makes them not good candidates for speculative gains but candidates for intra-Africa portfolio diversification due to reduced investors' risk exposure to market synchronicity. Market participants could use IFRS adoption and compliance as a tool for selecting informative markets for investment in Africa. The findings further support IFRS as a catalyst in deepening stock market price informativeness. Therefore, African countries which have shifted to or are in the process of shifting to a market-based economy should consider the adoption of IFRS to propel the stock market development through informativeness.

7. LIMITATIONS AND DIRECTION FOR FUTURE STUDIES

Stock markets generally develop policies and infrastructure when migrating or adopting a new framework as sensitive as IFRS so as to mitigate possible negative integration lapses and enhance the benefits of such a framework. The potency or effectiveness of such localised interventions to enhance the magnitude of the consequence of IFRS-induced information flow to the market may create heterogeneity among African markets. However, this paper assumed homogeneity among the selected markets studied. This assumption could have influenced the outcome of this paper. It is therefore recommended that future studies explore some of these financial reporting interventions and conditions for IFRS-induced market informativeness on those localised interventions. Moreover, the paper observed a persistence decreasing trend in post-IFRS periods for about five years and began to revert. Although intuitive explanation has been provided, future studies could introduce rolling window and period transition to understand these dynamics.

Competing Interest

The authors do not have any known competing financial interests or personal interest that could influence the outcome of this research.

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NS global economics
ECONOMICS
Innovative and Economics Research Journal
Volume 12, No. 1, 2024
www.economicsrs.com

ANALYSIS OF THE PUBLIC TRANSPORT EFFICIENCY, PRODUCTIVITY AND ECONOMIES OF SCALE: THE CASE OF SFAX – TUNISIA

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Received 30.11.2023. | Sent to review 10.12.2023. | Accepted 26.03.2024.

Original article

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JEL Classification: D240, R410, R420

Doi: 10.2478/eoik-2024-0004

UDK: 656.073.24:005.336.1(611)

ABSTRACT

This study aimed to determine the efficiency and productivity of the production factors in the case of public transport in Sfax – the second most important agglomeration in Tunisia–. The analysis of factor productivity enabled identifying the shortcomings in the supply of this service and advocating certain strategies to boost supply. We use an estimation of the trans-logarithmic costs function with different restrictions while relying on the foundations of the microeconomic theory. We relied on annual statistical data from the Regional Transport Company in Sfax over the period preceding the COVID 19 crisis spanning from 1985 to 2018. The estimation results showed the presence of scale diseconomies, the gain in productivity over the years is too slow. The technical progress of public transport in Sfax is very low and the technical efficiency is also very limited. The results revealed that there is a decline in productivity growth due to a growing inefficiency throughout the study period.

The underutilization of production capacities in the transport sector was judged as a consequence of excess of capacity and lack of efficiency attributed mainly to the lack of competition. The study identified some external factors that have an impact on the measured efficiency but are outside the company control. Public authorities should act on these factors to help companies improve their performance. A deregulation of the public transport sector by redefining the most important objectives has become urgent.

Keywords: *Public transport, Efficiency, Productivity, Economies of Scale, Translog Cost Function*

1. INTRODUCTION

The relationship between transport and urban development is determined through two factors: (i) the demand effect: "an increase in economic activity requires more transport", this is the most prevalent and most cited effect; and (ii) competitiveness effect or feedback effect: "a better transport leads to more economic activities". The productivity of urban transport contributes to the overall productivity of the economy. The demand for transport is generated by the demand for other goods and services, and the resulting need for mobility. An efficient transport sector improves the standard of living of individuals and households by participating in the reduction of costs and prices of other goods and services. However, urban transport is often as accused of being responsible for several problems faced by cities. Some economic and ecological problems, such as global warming, air pollution noise and the rising fuel prices are said to be direct consequences of urban transport.

Owing to its high capacity, low CO_2 emissions, and alleviation of traffic congestion, public transport has become an important alternative in ensuring citizens' mobility. Policies giving priority to public transport are generally widely appreciated. The answer to the question "To what extent such policies can impact travelers' attitudes in a complex traffic environment" remains unclear. In order to encourage citizens to rely more on public transportation, reduce private car travel, and reduce congestion, the policy has made some efforts that are clearly noticeable in two aspects. On the one hand, it encourages the use of public transport by improving service quality and reducing travel costs, public transport subsidies, and bus lane and signal priority. On the other hand, the use of private cars is reduced by imposing higher parking fees, restricting the purchase of cars, limiting access to city center alternatively to odd and even number plates, and collecting road tolls (Zhu, Chen, Wang, & Ma, 2018).

Public transportation is one of the most important alternatives to reduce reliance on private cars. Compared to the private cars, public transport (public buses) is more environmentally friendly, efficient and sustainable (Moraliyska, 2023). Its use can be encouraged by improving service quality, reducing commuter fares, providing government subsidies, adjusting bus fares, and providing "park and ride" facilities, all of which have attracted considerable attention of the public transport systems, to relieve congestion. Traffic jams - especially in the city centre. However, in many cases, public transport operators/companies have traditionally balanced their income and expenses. They try to maximize their revenue through higher fares, which ultimately reduces the quality of service, which causes people to turn to personalized transportation for commuting (Ali, Nakayama & Yamaguchi 2022).

The frequently forwarded solution was to promote public transport over the long run. Managers of such companies often sought to improve the vehicles schedule, their spatial coverage, the quality of their service and the comfort of their passengers (renovation of the vehicle fleet, tramway construction, expansion of networks).

In Tunisia, the public authorities are currently adjudicated in favor of a more efficient and effective public transport system. Nevertheless, the public transport has always been on the decline compared to the other particular modes. Numerous factors may explain the abusive recourse of the use of private cars in urban areas. The door-to-door service, the choice of journey and departure time, comfort and flexibility of use are the major factors which advocate the use of the automobile (Makhlouf, 2013). The problems plaguing public transport supply in Sfax explain the users fleeing to private modes. In fact, they run away from the permanent imbalance between supply and demand, the irregularities of the frequencies, and the very uncomfortable travel conditions. These problems originate in the market structure of this service. The Regional Transport Company of Sfax, SORETRAS (Société Regionale des Transports à Sfax), is the monopoly that offers public transport services. Like most of public companies, it suffers difficulties related to the management and productivity of its factors of production, bureaucratic problems, centralization of decision making and financing by the appropriate ministry (Martin, 2023). For this public transport company, not only are fares and their variations set by the supervisory ministry, but it also depends on this ministry for staff recruitment, bus purchases and subsidies.

Taking into account these conditions, the purpose of this research was to examine the efficiency and productivity of the production factors in the case of public transport in Sfax. In this context, we sought to reveal whether the public transport company in Sfax enjoys a natural monopoly position and whether the sector should be completely deregulated by opening it up to competition. Similarly, calculating the factor efficiencies and productivity enabled us to explain the sources of these inefficiencies. The research study also investigated if the public monopoly and protectionism enjoyed by SORETRAS are at the root of these inefficiencies; and the possible innovations and management and organization methods that are likely to improve the conditions provided to the company of Sfax.

Most of the recent studies that have looked at the efficiency of public transport systems have taken a non-parametric approach relying the DEA (Data Envelopment Analysis), SFA (Stochastic Frontier Analysis) or other methods (Bugheanu, 2018; Vigren, 2016; Carvalho, Syguiy, & Silva, 2015; Karim & Fouad, 2019). These methods, however, are often used in the case of panel data and allow the classification of all the companies operating in this sector and the comparison of their efficiencies. In our case, since we dealt with only one firm, we have chosen to use a parametric approach to analyze its productive and allocative efficiency. We used an estimation of the translogarithmic costs function with equations that were added to the different restrictions while relying on the foundations of the microeconomic theory of the costs. Although this is a traditional approach, it is still valid for analyzing and explaining the problems of allocative and productive inefficiency of the firm in question, especially when using time series data. The calculation of the economies of scale would allow us to decide whether to be a in favor of the monopoly status enjoyed by the SORETRAS. The determination of the productivity of the factors and the calculation of the allocative and productive efficiency helped us to suggest the effective measures to possibly improve the performance of the public transport sector in Sfax. This study would enable us to provide some answers to the issues raised above, and suggest some measures susceptible to improve the performance of this sector (Alimi & Lassad, 2023).

The rest of this study is structured as follows: Section 2introduced the new challenges for the public transport and the renaissance of this sector in developed countries. Section 3 analyzed the supply and the demand of public transport in Sfax region during the period 1985 – 2018. Section 4 detailed the empirical approach and the obtained results. Finally, Section 5 concluded the study and provided some policy implications.

2. THE NEW CHALLENGES OF PUBLIC TRANSPORT

The past decades have witnessed a huge popularity of private cars use not only in Western countries but also in developing ones. The use of cars has increased considerably. Due to various mobility needs governed by physiological, psychological and economic reasons, new travel alternatives are emerging. To satisfy this growing travel demand, citizens tend to use private modes rather than public ones. These modal changes have been observed in developing countries, which ultimately led to major urban transport problems (Gajera, Dawda, Dave, Joshi, & Arkatkar, 2019).

Public transport has experienced a spiraling downward trend in terms of attendance, investment and service quality. In addition, territorial development and land use plans often focused on the use of the automobile (Candea et al., 2023). Moreover, some studies have argued that apart from a few large cities, there are few reasons to extend the public transport service or to encourage the use of this mode (Orski, 2000; Balaker, 2004). However, recent trends have increasingly favored the use of public transport. Recent studies highlight the advantages of this collective mode (Litman, 2006; Puentes, 2008). Many reasons have accelerated the shift of transport demand from private to alternative modes. Among these we can state the rising of fuel prices, increasing urbanization, traffic congestion, increased expansion and maintenance costs of the road network, and the evolution of consumer preferences.

The recent decades have revealed new demographic, urban and economic trends providing more support for an increased urbanization. Agglomerations have experienced a rapid shift towards becoming urbanized centers. Many areas, that were previously classified as suburbs, are gradually urbanizing. Their sizes and the resulting travel demand justify the authorities' resort to public transport. The increase of congestion, business clustering and parking problems make the investment in public transport more profitable and efficient. Traditionally, transport policies have always aimed at balancing supply and demand (Puška, Kozarević, Stević & Stovrag, 2018). However, for sustainability reasons, transport policies have undergone paradigm shifts, emphasizing the movement of passengers rather than vehicles. It is evident that public transport systems can mitigate the drawbacks associated with private vehicles and, therefore, contribute to sustainability goals (Dawda, Gajera, Joshi, Arkatkar, & Dave, 2020).

There is a rising awareness among transport professionals and general public that it is more beneficial to have a more diverse transport system (Pusher, 2002). Since the mid-1990s, public means of transport have grown in popularity at the expense of private ones. According to BTS[1] 2003, public transport trips in the USA increased by 24%, while the private automobile mileage increased by only 10%. This trend is predicted to continue in the future years. A renaissance of public transport is about to take place in major US and European cities. Increasing congestion in most of the cities and rising warnings to environmental issues make public transport the ideal alternative in cities (Fitzová, Matulová & Tomeš, 2018).

In small towns, the public means of transport mainly provide trips for the most disadvantaged. They are an adequate alternative for those who cannot afford a private car. It also supports development and equity goals. However, when these cities increase in size and density, this type of transport serves several discretionary categories (people who can use their cars). It offers significant benefits to city dwellers reducing traffic problems and supporting development and land use plans. Given the traffic conditions in these large agglomerations, some drivers prefer to drive less and to use more comfortable and more accessible alternatives. Satisfying this rising demand for alternative modes can provide a variety of benefits. Improving public transport is profitable measure of the whole urban transport system. Litman, 2010 enumerates several measures that allow to improve the public transport service and encourage its users. Among these we can cite:

- Increasing the supply of the service, through the extension of the network and the operation hours, and the increase in the number bus trips.
- Improving the coordination among and with the other modes; giving passage and parking priorities to public transport vehicles in order to reduce delays and increase the commercial speed; besides specific routes can be preserved for buses and non-motorized modes as a measure to improve their commercial speed.
- Making buses appealing to users through improving the comfort inside vehicles by limiting the number of passengers and taking care of cleanliness and comfort.
- Modernizing the bus stations and stops network, providing waiting seats, useful user information, and signaling the vehicle direction and itinerary.
- Adopting lower fares and providing special discounts for some customer categories, installing more convenient payment methods, and conducting marketing and information campaigns on the benefits and advantages of public transport, real-time information about the vehicle's arrivals and departures.

Other strategic and long run measures have to be taken like promoting development focused on public transport ; getting better access to stops and stations for the pedestrians and cyclists;

[1] BTS : "the Bureau of Transportation Statistics"

ensuring an easier and more appropriate combination of the public transport with the other modes (walking, bicycle, private car and carpooling); conceiving adequate vehicles, stations and pedestrian crossings that can accommodate people with special needs, increasing safety for public transport users and pedestrians; issuing “Access Guides”, including all necessary information about travel and pointing such specific needs as express suburban bus services during special events. As it was cited by Sénquiz-Díaz for the relation between transport infrastructure and economic performance, (Sénquiz-Díaz, 2021). The government should prioritize the integration of other logistics and urban transport players into the public sector to maximize the benefits of the networks (Al-Ansari & Al-Khafaji, 2023). Thus, the importance of transport infrastructure and logistics should not be overlooked, as logistics providers play an important and relevant role in practice (Aytekin, Korucuk, & Karamaşa, 2023).

The improvements and incentives for the collective mode tend to offer significant advantage. These may even be more significant when the public transport substitutes automotive travels (Liu & Wang, 2023). It is notably an economical advantage through achieving several savings on vehicles costs, the renunciation of driving, reducing congestion, parking cost savings, increasing road safety and security, economizing of energy and the cutting down polluants emissions. Shifting from a reliance on private cars to public transport allows not only lower variable or operating costs, but also fixed costs which are independent of the traveled mileage (Kuncoro & Fafurida, 2023). Indeed, this substitution can result in a renunciation of some consumers of using their cars or even buying one (Litman, 2016). McCann established that the US households, in collectivities enjoying good public transport conditions, can economize on average about $ 3,000 per year on travel costs (McCann, 2000). Litman found that annual savings of transport cost of about $ 1,300 per household in cities having rail transport systems, compared to other cities. A better public transport system can result in remarkable effects on the economic and social development of a region or a country (Litman, 2004). The table below summarizes the different economic impacts and how they can be measured.

Table 1. Impact of public transport improvements on economic developmen

Category	Description
Employment and activity level	Increasing the volume of transactions, economic activity and employment opportunities.
Consumer expenditure	Some expenditures will be transferred to other consumptions.
Effectiveness of facilities	Increase of accessibility providing better efficiency of agglomerations
Productivity profits	Improvement of the access to education and jobs, and reduction of costs for companies by reducing travel time and costs for employees and students and reducing goods delivery costs and energy consumption for companies.
Economic development strategies	Supporting development strategies and increasing the opportunities of achieving the objectives
Effectiveness of the transport system	Reducing unit costs and improving the performance of the sector.

Source : Litman (2015)

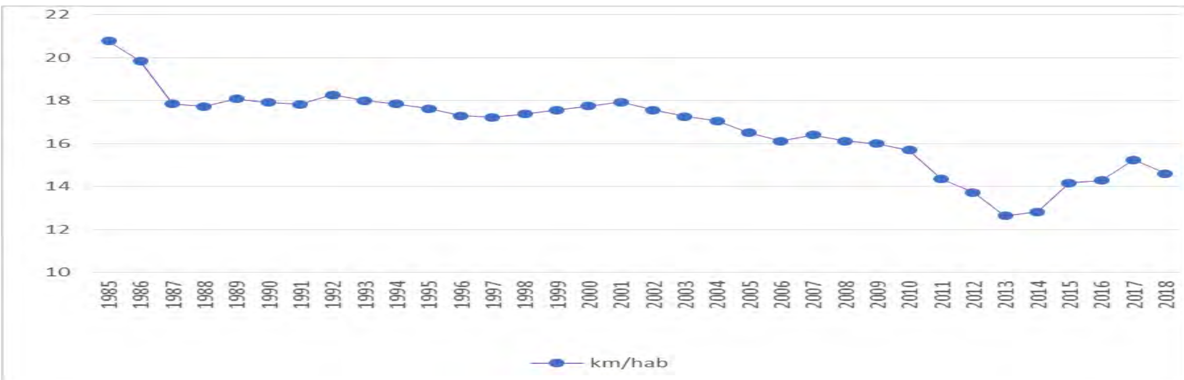
Given all these advantages, the organization of urban spaces and the management of mobility in large agglomerations inevitably require the rehabilitation and reorganization of public transport. Its capacity to ensure the displacements of a large number of users enables this sector to rank first while examining the transport policies that can be adopted. The specificities of each region and city make it almost impossible to suggest universal measures that would suit them all. The scope and effectiveness of policies largely depend on the diagnosis of the current status of an urban transport system. Thus, in the following section, we proceeded with a descriptive analysis of the public transport system in the region of Sfax, Tunisia.

3. PUBLIC TRANSPORTATION IN SFAX REGION

Sfax city is the second pole of Tunisia. It hosts a population of one million inhabitants in 2017, among which 65% live in the urban area of "Grand Sfax". This agglomeration is characterized by a strong urban sprawl, and a low density of urbanization (30 inhabitants / Ha). The spatial organization is radio-concentric. The infrastructure of land transport consists principally of 14 radials and four radial roads. The traffic on the various radials is too dense to reach the center easily. 40,000 vehicles per day are recorded on some sections. Traffic conditions, especially during rush hours, are difficult due to the intersections saturation and anarchic parking. On the institutional level, the Ministry of Transport remains the major authority organizing the urban transport in the city with an extremely limited role of local collectivities. Their involvement is weak especially in the planning and programming phases. This is not specific to the region of Sfax but characteristic of all the governorates of the country. The SORETRAS- local transport company- is a public monopoly of urban and regional transport. The urban public transport network involves about 30 regular lines with an average length of 20 km (round-trip). Substantially, all of these lines converge towards the city center, which causes overloaded journeys in some cases and empty returns in others.

The public transportation supply is measured by "Vehicle kilometers per inhabitant" statistics. Initially, there has been a relative stability in the service supply during the Tunisian pre-revolution period in 2011. This is explained by the fact that the public transport supply is not correlated with the demand. Most of the diverse company vehicles trips were set for equity and social stability reasons. The huge number of lines and journeys exclusively devoted to students constitutes one of the major reasons for this stability of the public transport supply in the region of Sfax. Several trips were achieved with a limited number of users.

Figure 1. Evolution of mileage per inhabitant

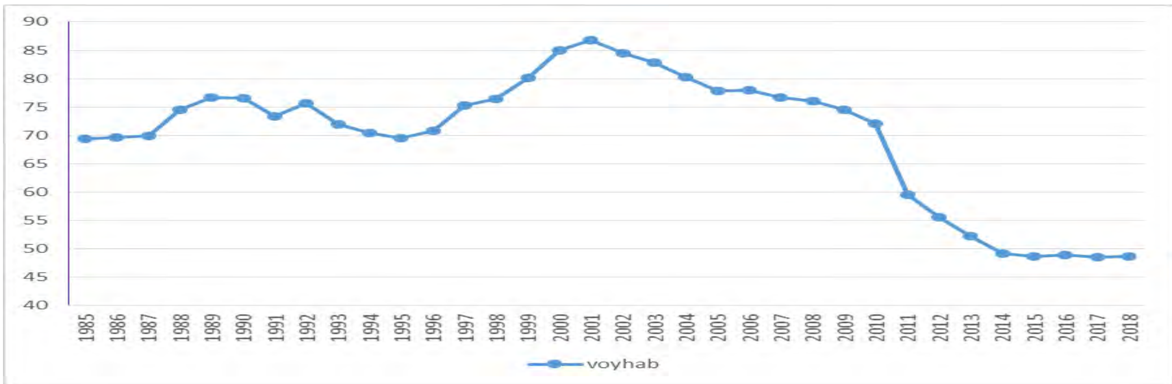


Source : processed by authors

Buses often ensure either driveways or almost empty returns. The existence of unexploited capacity is also due to the use of articulated buses, which are sometimes inadequate with the nature and schedule of some trips. The fall in supply observed in the period 2012-2014, is due to strikes and social movements. Thus, numerous trips are canceled, which reduces the number of kilometers traveled by the vehicles of the company.

To assess the demand for public transport by bus in this context, various studies opted for an aggregate which is the number of passengers transported per inhabitant. We can easily observe the considerable variation in demand during the period 1985-2018. The annual average of people transported per capita is 70. This is particularly explained by the quality of the network of public transport and the urban nature of the region. In Sfax, the SORETRAS essentially serves the urban areas, where demand is quite important. Together with the important number of the Sfax city inhabitants, the large number of students in this agglomeration could account for the increased resort to a collective mode for daily commuting. This category of users actually represents more than 80% of all the company customers.

Figure 2. Evolution of the number of travelers per inhabitants



Source : processed by authors

The urban spread, on the one hand, and the inability of the public transport system to meet the needs of commuting between the center and the periphery on the other hand, have led citizens to shift to private means of transport (taxis, motorcycles and passenger cars). This resulted in a considerable drop of public transport use in the motorized trips, from 30% in the early 1990s to nearly 20% today. The sharp rise of individual transport has aggravated the problems of congestion and pollution in the city of Sfax. The SORETRAS low service quality is also a fundamental factor explaining the users evasion phenomenon. Although the fleet in operation included more than 350 vehicles in 2005, the availability rate has declined steadily from 85% in 2000 to 54% in 2013, with a steadily aging fleet. In 2013, the average age of vehicles reached 7 years and 4 months for urban bus network and 10 years and 7 months for the inter urban one. This caused very uncomfortable travel conditions and continuous nuisance for the users. In addition, frequencies rose up to 60 minutes and the commercial speed continued to drop, especially when moving close to the city center.

In order to analyze the reasons underlying the disequilibrium between supply and demand of the public transport in Sfax, it is necessary to analyze the company's cost structure. This allows us to determine the productivity of the factors of production, identify the extent to which they are used efficiently and see whether the current organization of the market for urban public transport in Sfax is optimal or not.

4. EMPIRICAL ANALYSIS

4. 1. SAMPLE AND DATA

The data used in this study cover the operation of SORETRAS for the period 1985-2018. The choice of this period was dictated by the consequences of the covid-19 pandemic on economic activity and public transport in particular. Indeed, the containment, established in Tunisia for relatively long periods in the years 2020 and 2021, had a direct impact on urban mobility in the city of Sfax. Taking into account the statistics on public transport and the operation of the SORETRAS for these two years could affect the overall results of the estimated econometric model.

These data include production output (Y) expressed as the number of passengers per capita, labor force (L), capital stock at the beginning of each period (K) expressed by the number of available seats, energy cost value (VE), average annual salary (p_L), payroll (MS), energy price (p_E) and total cost (TC) which represents the sum of the variable cost (VC) and the fixed cost (FC). Table 2, presents the main descriptive results of the used variables.

Table 2 . Descriptive Analysis of variables

Variables	Y	K	L	VE	p_L	p_E	TC
Mean	70.18	31618.38	1379.529	3754949	13209.31	0.517	3.29 e+7
std dev	11.39	6140.04	65.86	2405366	9122.57	0.318	2.04 e+7
Minimum	48.58	23762	1284	1334526	3259.26	0.230	1.03 e+7
Maximum	86.73	43397	1518	8733108	36952.53	1.14	8.29 e+7

Source: Authors' calculation

We can note the small fluctuations in the value of output Y. As noted above, the evolution of the number of travelers is due mainly to the dramatic increase in the number of students at the end of the years 1990. This same production knew from the years 2004 onwards a continuous decrease explained by the competition by the collective taxis. The factors prices, P_L and P_E, are measured by the ratio of expenditures devoted to each of these factors to the number of workers and the quantities of fuel consumed. The increase in prices for these two factors is explained by the increase in wages and other advantages to the company's personnel, as well as by the surge in oil prices and their consequences during the last decade. Although the number of workers underwent small changes during the study period, staff spending rose steadily at incredible rates, especially during the years that followed the Tunisian revolution. Concerning the price of energy, the increase in world oil prices and changes in the price of gas oil in the domestic market explain the fluctuations of this aggregate. For the capital factor, we have chosen to consider it as a quasi-fixed factor. It is measured by the number of seats in all the vehicles of the company. It is the theoretical capacity of the vehicles noted K. The variations in this variable can therefore be explained by the changes in the SORETRAS fleet, following the acquisition of new buses or, the abandonment of other buses.

4. 2. TRANSLOG COST FUNCTION, TOTAL FACTOR PRODUCTIVITY AND TECHNICAL EFFICIENCY

To analyze total factor productivity and technical efficiency, most of the models used assume the full factor utilization and a long-run equilibrium state. They are generally based on the assumption that companies use efficient technological and economic combinations. Thus, productivity growth can be denoted by $\varepsilon_{ft} = \partial LnY/\partial t$, where Y is the output, and t represents the technological state, or $\varepsilon_{Ct} = -\partial LnC/\partial t$ where C is the total cost (Baldwin, Gu,& Beiling, 2013; Gu & Wang, 2013). The evolution of the total cost, based on technical progress, is represented by *dLnC/dt*. It describes the total response of inputs (variable and fixed) to long-run equilibrium levels.

$$\frac{\dot{C}}{C} = \frac{dLnC}{dt} = \frac{1}{C}\left[\frac{dC}{dt|_{X_m=\overline{X_m}}} + \sum \frac{\partial C}{\partial X_m}\frac{dX_m}{dt}\right] \quad (1)$$

This measure represents an estimate of long-run cost elasticity in the same way as long-run price and production elasticities. Indeed, the short-run Translog variable cost function with variable returns to scale (VRS) can be written as:

$$LnVC = \alpha_0 + \alpha_t t + \frac{1}{2}\gamma_{tt}t^2 + \sum_{i=L,E}\alpha_i Lnp_i + \beta_Y LnY + \beta_K LnK + \frac{1}{2}\sum_{i=L,E}\sum_{j=L,E}\delta_{ij}Lnp_i Lnp_j + \frac{1}{2}\gamma_{YY}(LnY)^2 + \frac{1}{2}\gamma_{KK}(LnK)^2 + \sum_{i=L,E}\rho_{Yi}LnYLnp_i + \sum_{i=L,E}\rho_{Ki}LnKLnp_i + \rho_{YK}LnYLnK + \rho_{tY}tLnY + \rho_{tK}tLnK + \sum_{i=L,E}\rho_{ti}t\,Lnp_i \quad (2)$$

The verification of the homogeneity with respect to the prices of degree 1 requires the imposition of the following constraints:

$$\alpha_L + \alpha_E = 1;\ \delta_L + \delta_E = 0;\ \delta_E + \delta_E = 0;\ \rho_Y + \rho_E = 0;\ \rho_K + \rho_K = 0;\ \rho_L + \rho_E = 0 \quad (3)$$

In order to reflect the optimization behavior and based on Shephard's lemma, it is useful to resort to other additional equations. These optimal demand or cost minimization equations (variable cost shares, Si) results from the logarithmic differentiation of the variable cost function with respect to variable input prices logarithms Lnp_L and Lnp_E knowing K, Y and T. Indeed,

$$S_i = \frac{\partial LnVC}{\partial Lnp_i} = \frac{p_i X_i}{VC} = \alpha_i + \delta_{ii}Lnp_i + \delta_{ij}Lnp_j + \rho_{Yi}LnY + \rho_{Ki}LnK + \rho_{ti}t \quad (4)$$

$$\forall\, i \neq j = L, E$$

By imposing the different restrictions on the cost function as well as the parts share equations, we will have the system of equations (5). To solve the singularity problem, it is necessary to eliminate the equation S_E from the fact that $S_L + S_E$. The system is estimated by the iterative SURE method under constraints of Zellner (Zellner, 1962).

$$\begin{cases} Ln\left(\frac{VC}{p_L}\right) = \alpha_0 + \alpha_t t + \frac{1}{2}\gamma_{tt}t^2 + \alpha_E Ln\left(\frac{p_E}{p_L}\right) + \beta_Y LnY + \beta_K LnK + \frac{1}{2}\delta_{EE}Ln\left(\frac{p_E}{p_L}\right)^2 + \frac{1}{2}\gamma_{YY}(LnY)^2 + \frac{1}{2}\gamma_{KK}(LnK)^2 \\ \qquad + \rho_{YE}LnYLn\left(\frac{p_E}{p_L}\right) + \rho_{KE}LnYLn\left(\frac{p_E}{p_L}\right) + \rho_{YK}LnYLnK + \rho_{tY}tLnY + \rho_{tK}tLnK + \rho_{tE}tLn\left(\frac{p_E}{p_L}\right) \\ S_L = \alpha_L + \delta_{LE}Ln\left(\frac{p_E}{p_L}\right) + \rho_{YL}LnY + \rho_{KL}LnK + \rho_{tL}t \\ S_E = \alpha_E + \delta_{EE}Ln\left(\frac{p_E}{p_L}\right) + \rho_{YE}LnY + \rho_{KE}LnK + \rho_{tE}t \end{cases} \quad (5)$$

After applying the homogeneity and concavity restrictions, the average variable cost (CV) equation and the demand equations are the equations to be estimated in the short run. If we assume that the cost function is $y_i = \alpha_i + \beta' X_i + \varepsilon_i$, then, the error term can be identified as $\varepsilon_{it} = v_i + u_t$. The Panel's error can be defined as the sum of the behavioral errors u_{it} and an individual specific effect v_i. This individual effect can be estimated by using fixed or random effects models. To improve the efficiency of the estimation of the cost function parameters and the corresponding demand equations, a seemingly unrelated iterative constraint regression of Zellner (1962) is often used.

The concept of elasticity plays a central role in econometric models because of its synthesizing property. From a methodological point of view, elasticity might appear, only with the estimated coefficients of the equations. The logarithmic form of the Translog cost function facilitates the imposition of constraints and the calculation of elasticities in order to explain the impact of input prices on the costs and the quantity of output and capital.

For the ASE (Allen Substitution Elasticities), elasticities of substitution between inputs, we note σ_{ii} the direct price elasticity of factor i, and σ_{ij} the price elasticity for factor i following the change in the price of factor j. Indeed,

$$\sigma_{ij} = \frac{\partial LnX_i}{\partial Lnp_j} = \frac{\partial X_i}{\partial p_j}\frac{p_j}{X_i} \text{ and } \sigma_{ii} = \frac{\partial LnX_i}{\partial Lnp_i} = \frac{\partial X_i}{\partial p_i}\frac{p_i}{X_i} \text{ so that}$$

$$\sigma_{ij}^{CT'} = \frac{\delta_{ij} + S_i S_j}{S_i} \text{ and } \sigma_{ii}^{CT'} = \frac{\delta_{ii} + S_i^2 - S_i}{S_i} \tag{6}$$

Farrell was the first to conceive of a firm's efficiency as being the product of two components (Farrell, 1957) : technical efficiency defined as the ability of the firm to produce as much as possible of outputs from fixed quantities of inputs, and the allocative efficiency which reflects the firm's ability to use its inputs in optimal proportions with regard to their respective prices. A random error term v is added in relation (2). We thus obtain a composite error model:

$$y = f(x, \beta) + (v - u) \tag{7}$$

$u \geq 0$ and $-\infty \leq v \leq \infty$ v represents the variance due to the contingencies which influence production and which are not directly under the control of the manager. Moreover, v and u are independent of each other as well as of x. The relationship (7) can be re-parameterized as follows:

$$y_i = \beta_0' + \sum \beta_j x_j + \varepsilon_i' \tag{8}$$

With $\beta_0' = (\beta_0 - \mu)$ and $\varepsilon_i' = v_i - (u_i - E(u_i)) = v_i - (u_i - \mu) = \varepsilon_i + \mu$

To estimate the technical efficiencies from (8), a particular distribution must be specified for each of the error terms. We can first estimate μ by the method of moments and then β_0 (Aigner, Lovell, & Schmidt, 1977). Indeed, from the residual vector $\hat{\varepsilon}'$ of (8), one can obtain an estimate of the moments of order two ($\hat{\mu}^2$) and three ($\hat{\mu}^3$) and therefore of $\hat{\sigma}_u^2$ and $\hat{\sigma}_v^2$. The variances $\hat{\sigma}_u^2$ and $\hat{\sigma}_v^2$ are convergently estimated by:

$$\hat{\sigma}_u^2 = \left[\hat{\mu}_3 \sqrt{\frac{2}{\pi}}\left(\frac{\pi}{\pi - 4}\right)\right]^{2/3} \text{ and } \hat{\sigma}_v^2 = \hat{\mu}_2 - \left(\frac{\pi - 2}{\pi}\right)\hat{\sigma}_u^2 \tag{9}$$

The estimation of the center moments is given by the following formulas:

$$\mu_2 = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}(\varepsilon_{it} - \bar{\varepsilon})^2 \text{ and } \mu_3 = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}(\varepsilon_{it} - \bar{\varepsilon})^3 \tag{10}$$

Which correspond to the moment equation of Schmidt and Lovell (1979):

$$\mu_2 = \frac{\pi - 2}{\pi}\sigma_u^2 + \sigma_v^2 \text{ and } \mu_3 = \sqrt{\frac{2}{\pi}}\left(\frac{4}{\pi} - 1\right)\sigma_u^3 \tag{11}$$

Cost inefficiencies are estimated by the mean of the conditional distribution of u_{it} knowing ε_{it}, (Jondrow, Lovell, Materov & Schmidt, 1982) using the following expression:

$$E(u_{it}|\varepsilon_{it}) = \left(\frac{\sigma_u \sigma_v}{\sigma}\right)\left[\left(\phi\left(\frac{\varepsilon_{it}\lambda}{\sigma}\right) \Big/ \Phi\left(\frac{\varepsilon_{it}\lambda}{\sigma}\right)\right) + \frac{\varepsilon_{it}\lambda}{\sigma}\right] \tag{12}$$

$\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\lambda = \sigma_u / \sigma_v$ and $\phi\left(\frac{\varepsilon_{it}\lambda}{\sigma}\right)$ and $\Phi\left(\frac{\varepsilon_{it}\lambda}{\sigma}\right)$ are the density functions of the standard normal probability and of the respective distribution.

4. 3. ESTIMATIONS AND DISCUSSIONS

Following the correction of the serial correlation and the heteroscedasticity adjustment, the estimation of the final iterative SURE model is summarized in Table 3. From this Table, we can conclude that the translog variable cost function at VRS shows the economic evidence concerning the signs of the production factors and especially those of the quasi-fixed capital. In fact, the convexity with respect to *K* and concavity relative to the prices of variable inputs are verified.

Table 3 . Estimation results

Variables	Value	Std Deviation	t-statistic	p-value
Constant	10.84	10.18	1.06	0.287
β_K	1.81	1.65	1.1	0.272
β_Y	3.47	3.85	0.9	0.367
α_E	-0.52	0.25	-2.06	0.039
α_L	-0.99	0.19	-5.35	0.000
δ_{EE}	0.12	0.005	21.7	0.000
δ_{LL}	0.12	0.005	21.7	0.000
δ_{LE}	-0.14	0.004	-33.14	0.000
γ_{KK}	-0.13	0.27	-0.48	0.633
γ_{YY}	-0.19	0.43	-0.44	0.663
ρ_{YK}	-0.22	0.27	-0.82	0.410
ρ_{YL}	-0.043	0.009	-4.40	0.000
ρ_{YE}	0.043	0.009	-4.40	0.000
ρ_{KL}	0.033	0.02	1.62	0.106
ρ_{KE}	-0.033	0.02	1.62	0.106
α_t	-0.19	0.05	-3.89	0.000
γ_{tt}	-0.5 e-3	0.2 e-3	2.35	0.019
ρ_{tY}	0.015	0.6 e-2	2.25	0.024
ρ_{tK}	0.013	0.8 e-2	1.67	0.096
ρ_{tL}	-0.15 e-2	0.4 e-3	-3.24	0.000
ρ_{tE}	0.15 e-2	0.4 e-3	-3.24	0.000
R^2_Cost	0.98			
$R^2\_S_L$	0.90			

Source : authors' calculation

The estimated coefficients have conforming signs to those recommended by the economic literature and mentioned previously, in particular that of $\gamma_{K} > 0$. The energy factor is negatively correlated with the capital, which justifies the effect of substitutability between these two factors and especially because of the increase in oil prices over the past few years. The majority of trend effects are significant in at least 5%, but with different amplitudes except for that of the production which will influence the level of technical progress.

Starting from the findings of the cost Translog at RENC, we evaluated all the technical efficiency estimations, of the elasticities, of the economies of scale and of the technical progress in terms of parameters estimated based on the theoretical developments of the second section. Table 4 summarizes the major results found for some years and for the entire research period in which we specified the overall growth rate (*R*) and the average annual growth rate (*r*).

Table 4. Descriptive Analysis of the estimated scores

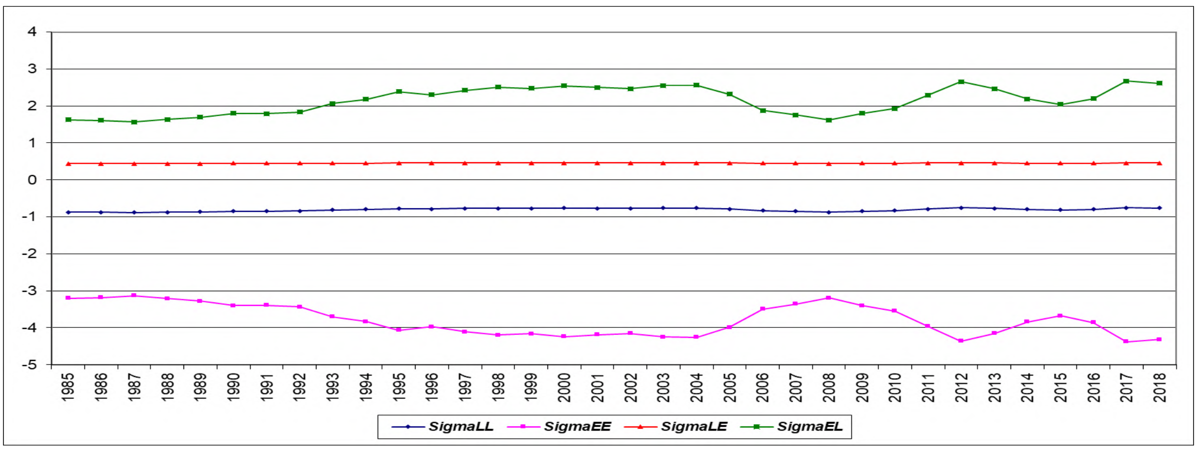
Year	**Economies of scale**	**Technical Progress**	ε_{LL}	ε_{EE}	ε_{LE}	ε_{EL}	**Technical Efficiency**
1985	0.270	-0.078	-0.874	-3.197	0.444	1.626	0.821
2000	0.090	0.028	-0.764	-4.238	0.458	2.543	0.958
2018	0.025	0.096	-0.758	-4.316	0.459	2.615	0.518
Average	0.170	0.019	-0.807	-3.790	0.452	2.145	0.751
Std dvt	0.246	0.063	0.043	0.414	0.005	0.0.366	0.129
R	-90.6%	-222.6%	-13.3%	35.0%	3.3%	60.8%	36.9%
r	6.9%	-200.6%	-0.4%	0.9%	0.1%	1.5%	-1.4%

Note : *R* : Overall growth rate; *r* : Average annual growth rate.

Source : authors calculations

In addition, to better explain the economic situation of the SORETRAS company, we resorted to a number of figures showing the evolutions of the major estimated aggregates. We calculated the price elasticities of production factors demand (own price elasticity for each factor and cross price elasticity between factors). The net price-elasticities show how the production factor *i* demand evolves when its price increases or decreases. For cross prices elasticities, it indicates how the production factor *i* demand evolves when the price of another factor increases or decreases. Table 4 shows these elasticities. Cross prices elasticities are positive. The production factors taken into consideration in our formalization of the variable costs function are then a priori substitutable. This may seem absurd at first. A substitution between work and energy (and more precisely fuel) is hardly conceivable.

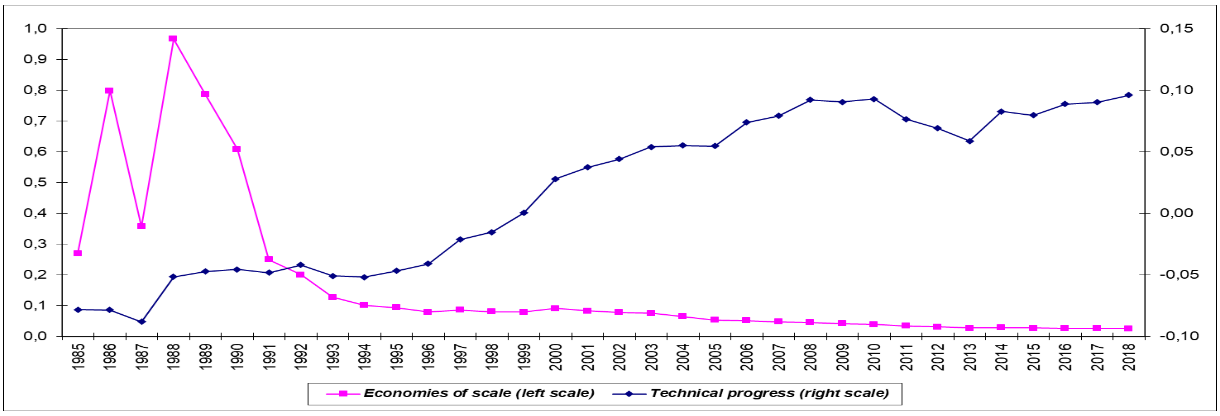
Figure 3. Evolution of short-term prices elasticities



Source : processed by authors

The additional demand of factors, and essentially that of labor, results in a cost increase, often, at a faster pace. Indeed, this increase in demand is reflected in a rise in overtime hours, but not in an increase in the number of workers. The labor cost as above defined increases considerably. The amount of fuel increases and its price is almost the same. This can therefore be considered as a substitution between the two factors.

Figure 4. Evolution of the technical progress and the economies of scale



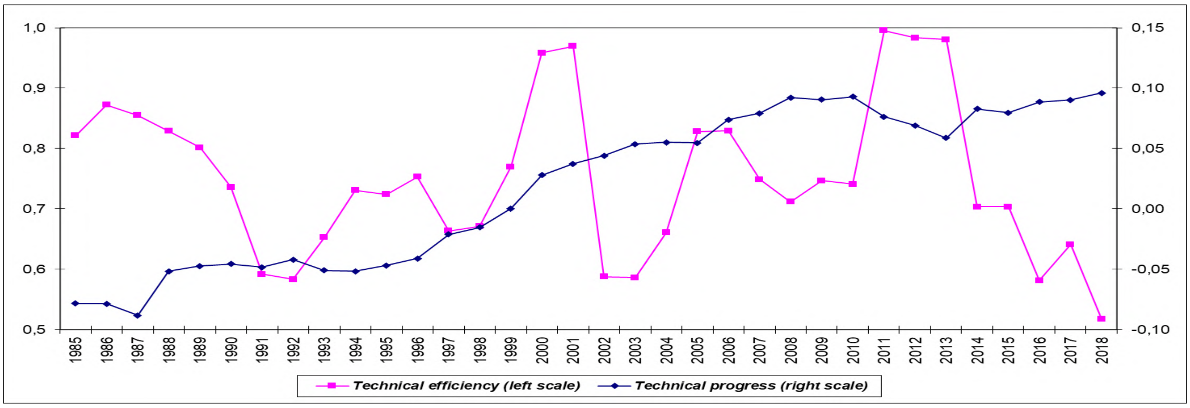
Source : processed by authors

The price elasticities values indicate a negative sensitivity of the cost compared to the price of these inputs. This is in total agreement with the teachings of microeconomic theory. These elasticities are relatively high. The expenditures of the company are then more sensitive to factor price increases than to the production variation. The increase of costs is generally caused by increases in staff and energy expenditures rather than the increase of demand. The decline even in production, during the past decade, has been accompanied by a significant increase of the costs. The syndical pressures and the social movements suffered by the company are in fact at the origin of this paradoxical relationship between costs and output level. This results in the degradation of labor productivity. On the other hand, the rise in oil prices on the world market and relative stability of the traveled distances are at the origin this high sensitivity of the costs relative to the price of the energy P_E.

As far as the economies of scale are concerned, and as shown in Figure 4, all the estimated values are low. Therefore, it is all about insensitivity of costs compared to the production volume. The decline in the number of the transported passengers, the rigidity of the demand of factors and the increase in their prices are the main reasons behind this weakness of scale returns. The traditional developments of the industrial economy result in resorting to the concept of economies of scale to determine the efficient market structure. They consider that the less than "1" values of the scale elasticities justify the competitive structure of the market. Such is the case in our study. However, the recent developments prove that this is still insufficient, especially when it is about a multi-product industry. In the case of the public transport market in the region of Sfax, we can already say that the SORETRAS company undergoes a very tough competition on this market. On the urban segment, the collective taxis are in fact just providers of a highly substitutable service to that offered by the SORETRAS. These taxis are micro-enterprises that are direct competitors of the public company. Their structures, sizes, ways (illegal) with which they operate, are all factors in favor of these mode. Sfax transport company is facing an unfair competition with these taxis, which led to the fall of its share on the market. Similarly, on the interurban segment, besides the competition faced from the other public transport companies, hired cars are other rivals of the SORETRAS.

The negative effect of time on the production costs can be interpreted as a technical progress within the company over the years. The estimated technical progress for the period of study presents quite low values (Figure 5). The average is 1.9%. Indeed, the use of such production factors remained relatively the same over the study period. The innovations at the level of the means or methods of work are too limited. The technical progress can be clearly noticeable at the level of the administrative work and of the workshops of maintenance. The use of new technologies and processes has reduced costs by limiting the workload. Since 2000, it can be observed that the elasticity of cost across time has become positive. This results from the costs increases of other variables that affect the company's operations.

Figure 5. Evolution of technical progress and technical efficiency



Source : processed by authors

The technical efficiency indicates the utilization rate of factors in the company. This rate increases on average at 75%. In other words, 25% of the factors available to the company are under-exploited or even unexploited. The SORETRAS relies on aging vehicles, the unavailability of an important part of the fleet and the obligation to satisfy the demand even when it is low, are elements which, to a great extent, explain this inefficiency of the company activities. Furthermore, it can be admitted that the SORETRAS inefficiently assigns the tasks to its personnel. A large number of the trips are aimed for schools where the use of two agents is almost useless since almost all the users have their prepaid subscriptions. It is therefore more judicious to call for a driver only.

Figure 5 shows the instability of the technical efficiency. However, this efficiency can be observed to have been on a steady decrease since 2013. The increase in the workers' salaries was related neither to the volume of their achieved work nor their productivity, which explains the drop in the efficiency score for this period. Moreover, the low efficiency value is due to an underutilization of the capital as a fixed factor; in fact, the decline in the number of seats offered during those years has had no effect on the number of transported people (Y) and on costs. The acquisition of new vehicles has not even helped in reducing fuel consumption.

Finally, all of our results highlight the several problems public transport suffers from in Sfax, such as diseconomies of scale, low factor productivity and technical progress, and loss of efficiency. This can be explained by several factors, some of which are exogenous and others are internal to the company. The exogenous factors are linked to the general macroeconomic situation, the political and social situation of the country, and the institutional and legal framework mainly in the recent past years. As for internal factors, the most important is the weak corporate governance regime.

The monopoly position of the public transport market in Sfax enjoyed by SORETRAS company is no longer economically justified. Market restructuring should be considered as soon as possible. A better allocation of resources and better governance have to be introduced and reinforced. In this context, even partial privatization can be a solution. However, the social, political and economic framework in Tunisia seems to be unfavorable to such measures. Moreover, these problems of efficiency and poor governance characterize the functioning of all public enterprises in Tunisia while economic reforms are installed at a very slow pace.

5. CONCLUSION AND IMPLICATIONS

In the current research, we first highlighted the importance of public transport for the community. The analysis of the characteristics of the public transports' market in the region of Sfax has allowed us to extricate an increasingly significant disequilibrium between supply and demand. To explain this market dysfunction, we resorted to analyze the SORETRAS costs and efficiency. We also used the Translog variables costs function estimation for the period 1985-2018 as the means to analyze the productivity and the technical efficiency within the company. The major contribution of this research was to capture a preliminary image of the efficiency of public bus transport in Sfax - Tunisia using limited available data. This might also be one of the main shortcomings of the study. Indeed, the availability of other socio-economic data for the Sfax region could have enabled us to identify the external factors influencing the performance and efficiency of the urban transport system in Sfax.

The estimation results showed the presence of scale diseconomies. This result suggests that the company does not enjoy a natural monopolistic position. The need to open the public transport market in Sfax to competition is obvious since the SORETRAS public monopolistic position has no economic foundation. Moreover, the decline in the modal share of public transport in Sfax compared to other modes, mainly collective cabs, justifies the urgent need to open this market to competition. The relatively high sensitivity of costs to factor prices is, in fact, the result of increases in wages and fuel prices, which are not linked to changes in production. It is therefore necessary to adapt wages to workers' productivity and improve the correlation between wage increases and production growth. the reduction in energy consumption could be achieved by reducing the number of empty trips and improving vehicle maintenance. Similarly, the gain in productivity over the years is too slow. The technical progress of public transport in Sfax is actually very low. Innovation, in terms of methods and used means, is, indeed, too limited and involve only the administrative aspect and equipment maintenance. The technical efficiency is also very limited as huge production capacities are often unexploited. Numerous factors intervene to explain these results, among which we can enumerate the rigidity of demand of the factors and the increase in their prices; the syndical pressures; the aging vehicles of the SORETRAS; the unavailability of a significant number of vehicles of the fleet during the years of study; the absolute need to satisfy the required demand even when it is free or low and the unfair competition with taxis and hired cars.

A number of managerial and political implications could be drawn from this study. From a managerial viewpoint, the results inform the company management, regional and national authorities of the company's position in terms of efficiency and its scope for improving its performance (increasing production or reducing inputs to become efficient). From a political viewpoint, the study identified some external factors that have an impact on the measured efficiency but are outside the company control. Public authorities should act on these factors to help companies improve their performance. Thus, the deregulation of the public transport market in Sfax and in Tunisia in general, the structuring of bus networks and the creation of a public transport network are strongly recommended. Moreover, a deregulation of the public transport sector has become an urgent measure. However, this deregulation should by no means be seen as privatization, given the social importance often associated with public transport. It seems, therefore, fundamental to redefine the most important objectives of the sector. This requires a capacity of a credible expertise, that is to say, a good knowledge of the technology in place and an improvement of the productive capacities and efficiency. Only when such objectives are achieved will the establishment of contractual structures prove perfectly relevant and effective. Finally, as a research perspective, we plan to collect data on the citizens' behavior in terms of demand for transport, in order to determine their needs and the improvements to be carried out to make this service more appealing.

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Innovative and Economics Research Journal
Volume 12, No. 1, 2024
www.economicsrs.com

THE ROLE OF STRESS TESTS IN ENHANCING BANK TRANSPARENCY: A COMPARATIVE STUDY OF ISLAMIC AND CONVENTIONAL BANKS

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Received 20.11.2023. | Sent to review 30.11.2023. | Accepted 05.04.2024.

Original article

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JEL Classification: G21, C22, D81, G32, G14

Doi: 10.2478/eoik-2024-0003

UDK: 336.763:338.124.4(28))

ABSTRACT

The global financial crisis highlighted the crucial role of stress tests in evaluating a bank's resilience to severe economic shocks. Accordingly, the purpose of the study was to examine the contribution of stress tests to credit risk in terms of hedging banking opacity and improving financial resistance against negative shocks in MENA countries, observed for the period from 2012 to 2022. Furthermore, , this study explores the impact of stress tests on enhancing bank transparency, particularly within the contexts of Islamic and conventional banking systems using the Panel-VAR and GMM approach. A conceptual framework is established to explain the connection between stress testing and bank transparency, emphasizing on the mechanisms through which stress tests can promote greater disclosure and accountability. A comparative analysis of stress testing practices across both banking sectors reveals similarities and distinctions in scenario selection, modeling techniques, and disclosure practices. In-depth case studies of Islamic and conventional banks illustrate the practical application of stress testing in fostering transparency. These results show that stress tests produce information about credit risk exposure and about the real conditions of financial institutions. Therefore, more transparency on bank losses and risks would have also enabled bank regulators to focus more attention on financial institutions and react early to take "corrective measures". Policy recommendations are drawn to enhance the effectiveness of stress testing in promoting transparency and financial stability within both Islamic and conventional banking sectors. This study contributes to a deeper understanding of stress testing's role in fostering a more resilient and stable financial system.

Keywords: *Stress tests, Panel-VAR, credit risk, Islamic banking, macroeconomic and specific shocks, financial stability*

1. INTRODUCTION

The real concern of current research is to gather relevant information to understand better the risks faced by individual banks and thereof to shape regulation to strengthen the financial stability of the banking system (Buston, 2015). In fact, Mishkin (1999) pointed out that an increase in information asymmetry problems and financial instability is mainly due to the following factors: higher interest rates, greater uncertainty, and deterioration of non-financial balance sheets as a result of changes in asset prices. For example, Myers and Majluf (1984) argue that in the face of asymmetrical information, shareholders make inefficient investment decisions that generate risky securities that are not properly valued in the marketplace. Flannery et al. (2013) revealed that banking opacity could be destabilizing when the financial system is under stress. Accordingly, Blau et al. (2017) argue that banks are more opaque than other types of firms.

Thus, studying the source of banking opacity is vital for strengthening financial resilience. On the other hand, increased banking transparency promotes the development of a sound banking system and an enabling environment, which facilitates the strengthening of the credit chain and avoids financial crises (De Mendonça et al, 2013). According to FCIR (2011), one of the root causes of the crisis is credit risk. Loans set interest rates for the first two or three years, then were subject to adjustable rates, and as a result borrowers defaulted. However, the rise in loan-to-value ratios due to the facility of credit flows has led to mediocre credit standards. With the large accumulation of mortgages and other high-risk mortgages in the financial system, it seems that many people with limited ability to pay have received high-risk mortgages with fraudulent practices from money lenders.

These mortgages were issued to borrowers who had lower credit rating and whose loan-to value ratio was higher. Indeed, they have less collateral, and have a more or less worse credit history. This subprime market increased significantly from 2003 until 2005. The proportion of subprime mortgages (i.e., total subprime mortgages) as a share of the total U.S. mortgage market has been increasing between 10% in 2003 and 32% in 2005 (Mayer et al, 2009). Therefore, the opacity of the interest rate risk and borrowers' insolvency risk has created a bank credit risk. According to Chakrabarti (2015), credit risk may be defined as a client's inability to repay interest or principal or both at the same time.

The credit quality of lending portfolios in most regions of the world was relatively stable until the 2007-2008 financial crisis. For this reason, the assessment and in-depth understanding of asset quality and credit risk in the financial sector has become an important component of supervision oversight, that facilitates the identification of major vulnerabilities in the financial sector (Roland et al. 2013). However, the financial crisis and its diffusion through the entire financial system has recently questioned the effectiveness of the risk management model and its ability to manage unexpected events and avoid future crises (Jawadi and Louhichi, 2017). In response to the crisis and as part of the second pillar 2 of Basel II, the Basel Committee suggests stress tests as a prudential supervisory tool, where banks are required to consider more severe scenarios in order to produce results that are more in line with the real constraints observed in BCBS (2009). As a result, the purpose of disclosing financial information to the public is to restore trust and reduce banking opacity by helping investors distinguish between sound and vulnerable institutions (Petrella and Resti, 2013). However, to evaluate the contribution of stress tests to credit risk in terms of hedging banking opacity in MENA countries, we will examine credit risk resistance against macroeconomic and specific shocks in order to examine the contribution of stress tests to reducing banking opacity by means of measuring the resistance of the studied banks. Studying both types of banks (Islamic and conventionnel) allows policymakers and researchers to grasp the contributions of each system in promoting inclusion. This understanding is vital, in evaluating how effectively each model reaches segments of the population including individuals, with ethical preferences.

To that end, we examine a panel data consisting of 72 listed banks in 7 MENA countries observed over an eleven-year period from 2012 to 2022. Our procedure is as follows: First, we examine previous studies on the contribution of stress tests to reducing banking opacity and improving financial resilience. Second, we will review the literature on determining credit risk to better understand the relationship between the variables in our model.

According to Matthew et al (2004), "Stress testing" in each financial institution is a set of techniques designed to measure the sensitivity of a portfolio to a set of extreme but plausible shocks. Simply put, when there are significant changes in some risk factors, stress tests produce a numerical estimate of a particular sensitivity. For this reason, we adopt the VAR Panel approach and the Generalized Method of Moments (GMM). Concomitantly, we follow Abrigo and Love (2015) and examine credit risk responses to specific and macroeconomic shocks. For this latter analysis, we impulse response functions (IRFs) and variance decomposition (FEVD), which describes the reaction of one variable on another variable to adverse events, while maintaining all other shocks at zero. The premise on which this methodology rests is to identify a series of shocks and to determine the effect of these shocks as well as the instantaneous or long-term responses of some variables to certain impulses. The PVAR is an hybrid econometric methodology thar combines the traditional VAR approach, which considers all structural variables as endogenous, and the Panel data methodology, which makes it possible to explicitly include a fixed effect estimate in the model (Shank and Vianna, 2016).

The remainder of the article is organized as follows. Section 2 provides a brief review of the contribution of stress tests to reducing banking opacity and to improving resistance of financial institutions to extreme shocks. Section 3 provides an overview of the data and defines the variables used and describes the methodology employed. Section 4 discusses the results obtained. Section 5 concludes.

2. LITERATURE REVIEW

In this section, we review the literature on the contribution of stress tests to reducing banking opacity and strengthening financial stability. Generally, banks that frequently hide negative information increase the probability of future shocks through the information asymmetry factor (Kosmidou et al, 2016). Indeed, Flannery et al. (2016) suggest that disclosure of stress test results systematically provides important information about the tested banks. Accordingly, the purpose of disclosing the results on financial resistance to the public is to restore trust and reduce banking opacity by helping investors distinguish between sound and vulnerable institutions Petrella and Resti (2013).

Kok et al. (2023) investigate how stress testing can lower risk by taking advantage of variations in stress test intensity at the bank level. They use quarterly bank-level data for the period between 2015Q1 and 2017Q4 from the European Central Bank's confidential Supervisory Banking (SUBA) database17. They find that stress tests have the potential to influence bank risk rather than just being a regulatory checkbox exercise. They discover that, in comparison to banks that were not involved in this exercise, banks that took part in the 2016 EU-wide stress test later decreased their credit risk.

This study of Abad el al. (2023) investigate whether the opacity of data regarding banks' credit risk has decreased as a result of stress tests that were carried out in the US and the EU between 2009 and 2019. The original sample consisting of 540 American and 266 European banks. To investigate the factors influencing the shift in the opacity level after the disclosure, we constructed a panel data model.

After the disclosure, there is clear evidence of a decrease in the opacity of banks evaluated in the US ST; this reduction is more pronounced for banks that fail to pass the test. These findings lend support to the hypothesis that the ST programs, particularly for banks that fail to pass the test, mitigate the opacity of the US banking industry. According to data, the transparency of the banking system in Europe does not appear to have improved with the release of the ST results.

Due to its complexity, there is little proof that the information generated by the EBA programs has an impact on the information opacity of the banking sector and may not be sufficiently transparent or accessible to subjective interpretations.

Khammassi et al. (2020) examine the contribution of stress tests to reducing banking opacity and ensuring the financial resilience of liquidity risk in the face of adverse shocks. The sample includes 74 listed banks in 7 MENA countries, during the 2005–2015 period. used the generalized method of moments (GMM) to conduct two estimations of the panel-VAR approach. We concluded that stress tests could play a fundamental role in reducing banking opacity by producing relevant information about banks' risk exposure, their current circumstances and their ability to resist adverse events.

Abdymomunov and Gerlach (2014) proposed a new method for generating scenario curves to test the stress of banks' IRR exposure, using the Nelson-Siegel (1987) (NS) yield curve model. The data are zero-coupon Treasury interest rates at month-end at maturities of 1, 3, 6, 12, 12, 24, 36, 60, 84, 120, 240, and 360 months. The data are obtained from three sources. The study period stretches from 1985: M11 to 2012: M12. The results indicate that their scenario generation method produces a wider range of EVE estimates than alternative methods do. They noted out that, in comparison to previous methods, their method offers more information about IRR exposure.

Petrella and Resti (2013) assessed whether and how the 2011 European stress test can affect the stock price of banks. They selected 201 banks from the Thomson Reuters European Banks index (LBANKSER), representing more than 75% of the European banking sector in market capitalization. They followed standard event study techniques (Campbell et al. 1997) using cumulative abnormal returns. The model is estimated over a 200-day window. The results of these stress tests have been recently released to the public and led to the construction of 3400 data points for each of the 90 participating banks in an attempt to restore trust and combat banking opacity, making it easier for investors to distinguish between strong and fragile institutions.

At the time of the results, the market reacted significantly to the disclosure of the detailed resistance test results. Petrella and Resti (2013) found that the tested banks showed a positive reaction during the (-2, +2) window, while the untested banks experienced negative abnormal returns. The difference between the two groups is statistically significant and this means that the stress tests revealed new information about the tested banks. This confirms that the market is not able to anticipate the results of the tests.

In fact, the effect of stress tests on opacity and bank risk premiums depends on the type of available data in the market when the results are published. Goldstein and Sapra (2012) suggest that detailed disclosure is preferable to aggregate disclosure (such as aggregate capital deficiency) Also recognize that the benefit of disclosure of stress test results are that they enhance financial stability.

Using a theoretical model, Gick and Pausch (2012) demonstrate how a banking authority can commit to disclose the results of stress testing in order to effectively regulate the banking industry. This is achieved through a disclosure scheme where supervisors disclose information about the methodology (e.g., the signal generation process) and the results of stress tests (the signal). In general, they conclude that stress tests create value by improving information disclosure between the supervisor and investors.

Ellahie (2012) also studied the 2011 European stress test in order to determine whether results disclosure influences the information asymmetry. It uses bid-ask spreads for equity, spreads for credit instruments, and implied volatility of equity options as a measure of information asymmetry. It examined the stress tests of 78 European banks selected in 2009, 2010 and 2011. As a methodology, the author uses the Difference In Difference (DID) technique, where the effect of stress tests on bid-ask spreads and volatility is implicit. The author concluded that stress tests did not correlate with a significant decrease in information asymmetry.

However, We can draw the conclusion that stress testing give market participants useful information and can help minimize banking opacity. This finding confirms the informational role of stress tests, which is consistent with the hypothesis that stress tests contribute to reducing banking opacity.

3. METHODOLOGY AND DATA

To provide answers on the ability of stress tests to reduce banking opacity, this paper aims to study credit risk resistance of the studied banks against specific and macroeconomic shocks.

3. 1. EMPIRICAL METHODOLOGY

We use the VAR Panel approach to study credit risk response to specific and macroeconomic shocks. The idea on which this methodology rests is to identify a series of shocks and to determine the effect of these shocks as well as the instantaneous or long-term responses of some variables to certain impulses. The advantage of P-VAR is its ability to simulate portfolio-level loss distributions in subsequent years for financial institutions. We try to test the credit risk stress of a set of banks in the MENA banking system against macroeconomic and specific shocks using the Panel-VAR and the Generalized Method of Moments (GMM), like in Abrigo and Love (2015). The frequency is yearly, and the establishment and estimation of PVAR model is completed in the STATA 13 software.

We estimate the following equation to present the retained variables:

$$\mathbf{Y}_{i,t} = \mathbf{Y}_{it-1}\mathbf{A}_1 + \mathbf{Y}_{it-2}\mathbf{A}_2 + \ldots + \mathbf{Y}_{it-p+1}\mathbf{A}_p + \mathbf{X}_{it}\mathbf{B} + \mu_{it} + \mathbf{e}_{it} \quad (1)$$
$$i \in \{1,2,\ldots, N\},\ t \in \{1,2,\ldots,T_i\}$$

Where $\mathbf{Y}_{i,t}$ is a variable vector ($NPLs_{it}$, RIR_{it} , INF_{it}, GDP_{it}, $SIZE_{it}$, CAP_{it}) of bank i at time t. $\mathbf{X}_{it}$ represents exogenous variable vector, $\mathbf{A}_1, \mathbf{A}_2, \ldots, \mathbf{A}_p$ and **B** are vectors to be estimated

T is the year period (t=2012-2022), i denotes banks, μ_{it} and $\mathbf{e}_{it}$ represent random error term.

$NPLs_{i,t}$ **:** Credit risk is measured by the non-performing loans ratio, $CAP_{i,t}$ **:** The solvency ratio, $SIZE_{i,t}$ **:** Bank size, $RIR_{i,t}$ **:** The real interest, $INF_{i,t}$ **:** Rate inflation rate, $GDP_{i,t}$ **:** GDP growth rate.

We estimate PVAR presented in (1) using ordinary least squares (OLS) refer to Abrigo and Love (2015).

3. 2. DATA DESCRIPTION

The full sample spans 11 year (2012-2022) and comprises 48 conventional banks and 24 islamic banks from 7 MENA countries.

A. Credit risk (Npls)

Assessment and in-depth understanding of credit risk in the financial sector has become an vital component of prudential supervision, which enables the identification of key vulnerabilities in the financial sector Roland et al. (2013).

Credit risk: Credit risk is the possibility of loss that a lender may experience as a result of a debtor's failure to make contractual payments or as a result of an increase in the probability of the debtor's default as a result of downgrading as credit risk, Küçükkocaoğlu (2016).

NPLs ratio is a measure of credit risk. Accordingly, NPL as defined in Mpofu. T.R and Nikolaidou. E (2018), is equal to the following:

$$\mathbf{NPLs} = \left(\frac{\textbf{non-performing loans}}{\textbf{total loan}}\right)_{i,t} \tag{2}$$

B. Solvency

Solvency: Kingu et al. (2018) use this variable as an example of a representative type of financial risk indicator and capital adequacy ratio for banks. we measure solvency in the same manner as Psaila et al. (2019)

$$\text{Solvency} = \left(\frac{\text{Equity}}{\text{total assets}}\right)_{i,t} \tag{3}$$

Makri et al. (2014), and Chaibi and Ftiti (2015) suggest that managers of small-cap banks are encouraged to engage in risky lending practices, As a result, there is a negative correlation between NPLs and "solvency ratio."

C. Bank Size

Bank Size: The natural logarithm of the total banking assets is used to calculate the size of the bank, which is considered the most popular measure of bank size in banking literature Rahman et al (2012). Thus, we calculate the size of the bank using the formula: Bank size =Log (total assets). According to Louzis, D. et al. (2012), SIZE has an adverse effect on asset quality. When banks grow too big, monitoring and evaluating them becomes challenging because they take on more risk and may become "too big to fail.". Salsa and Saurina (2002) discovered a correlation between bank size and NPL that was negative.; they showed that a larger bank size allows for greater diversification, leading to an increase in non-performing loans. The NPL is negatively and significantly impacted by the bank's size (Singh et al., 2021).

D. Real interest rate

The borrowing rate also increasingly affects non-performing loans. Therefore, the government must create laws that will lower borrowing costs in the National Economy (Akinlo, 2014) The Real Lending Ratio (RLR) coefficients are positive. Therefore, households' NPLs are sensitive to changes in RLR (Abid et al., 2014).

E. Inflation rate

Economic stability, which promotes saving, investment, economic growth, and aids in maintaining global competitiveness, is made possible by low inflation. So, low inflation is a positive sign for economic growth. High inflation decreases the borrower's ability to pay off its loan by lowering its income, which raises the NPL, according to Singh et al. (2021). The inflation rate has a considerable positive impact on NPLs, according to Louzis et al. (2010), who used a dynamic panel data model to study the determinants of NPL in the Greek banking industry. Additionally, Ghosh (2015) examined the impact of NPLs on US commercial banks and discovered that inflation had a significant and positive impact on questionable loans.

F. GDP growth

GDP is an economic indicator. In fact, to evaluate an economic growth of the country, we use the GDP growth rate shown in equation 3 (Singh et al., 2021).

$$\text{GDP growth} = \frac{\text{GDP}_{i,t} - \text{GDP}_{i,t}}{\text{GDP}_{i,t}} \tag{4}$$

According to Castro (2013) and Chaibi and Ftiti (2015), the Real GDP growth rate and non-performing have a negative correlation. Louzis et al. (2010) investigated the factors that influence non-performing loans in the Greek financial industry using a dynamic panel data model, and they discovered that the real GDP growth rate had a negative impact on NPLs. Vogiazes and Nikolaidu (2011) investigated the factors that contributed to non-performing loans in the banking industry of Romania between 2001 and 2010. They showed that among the major determinants of non-performing loans in Romania are the rate of inflation the GDP.

However, Bofondi and Ropele (2011) discovered a negative correlation between non-performing loans and Italy's GDP growth rate between 1990 and 2010. The NPL of commercial banks is positively and significantly impacted by GDP growth, Singh et al. (2021). Roland et al. (2013) observed a negative impact of real GDP on NPLs. As well, Abid et al. (2015) found that real GDP negatively impacts NPLs (e.g. Khaled and Yusof, 2024).

3. 3. PANEL UNIT ROOT TESTS

The following table shows the outcomes of the several stationarity tests: We start by checking the stationarity of the variables. The results of the unit root tests of Levin, Lin and Chu; Im, Pesaran; Shin, ADF - Fisher Chi-square and PP - Fisher Chi-square indicate that the GDP, SIZE, CAP series are stationary in level and the NPLs, INF and RIR series are non-stationary, or order (1) integrated (see **Table 1**). As a result, we estimate the model using the first difference between the variables.

Table 1. Stationarity of conventional banks

			NPLs	INF	GDP	SIZE	CAP	RIR
LLC	NIV	cst	-8.49611 (0.0000)	-5.703 (0.0000)	-6.53155 (0.0000)	-17.3368 (0.0000)	-9.15486 (0.0000)	-12.1140 (0.0000)
		cst & tend	-0.81601 (0.2072)	-7.59718 (0.0000)	176.649 (0.0000)	-23.1230 (0.0000)	-21.3281 (0.0000)	-10.5699 (0.0000)
	1ère diff	cst	-6.28271 (0.0000)	-20.59 (0.0000)	-22.66 (0.0000)	-25.64 (0.0000)	-21.9153 (0.0000)	-35.0250 (0.0000)
		cst & tend	-5.86260 (0.0000)	-19.1579 (0.0000)	281.564 (0.0000)	-22.39 (0.0000)	-18.53 (0.0000)	-37.5401 (0.0000)
IPS	NIV	cst	-3.08532 (0.0010)	-3.469 (0.0003)	-3.055 (0.0011)	-8.6977 (0.0000)	-4.19407 (0.0000)	-7.32749 (0.0000)
		cst & tend	1.83209 (0.9665)	0.02778 (0.5111)	158.578 (0.0001)	-7.49844 (0.0000)	-5.44084 (0.0000)	-2.38950 (0.0084)
	1ère diff	cst	-6.06542 (0.0000)	-9.872 (0.0000)	-12.3882 (0.0000)	-12.08 (0.0000)	-11.0574 (0.0000)	-22.4969 (0.0000)
		cst & tend	-1.79104 (0.0366)	-2.91938 (0.0018)	193.023 (0.0000)	-4.19945 (0.0000)	-4.16817 (0.0000)	-11.7015 (0.0000)
ADF	NIV	cst	146.973 (0.0006)	130.80 (0.0105)	130.498 (0.0111)	251.222 (0.0000)	175.640 (0.0000)	214.749 (0.0000)
		cst & tend	123.226 (0.0320)	77.6419 (0.9149)	-3.17750 (0.0007)	259.517 (0.0000)	212.249 (0.0000)	166.523 (0.0000)
	1ère diff	cst	267.713 (0.0000)	278.202 (0.0000)	336.153 (0.0000)	313.050 (0.0000)	302.09 (0.0000)	538.241 (0.0000)
		cst & tend	185.072 (0.0000)	170.036 (0.0000)	-3.20382 (0.0007)	223.29 (0.0000)	220.16 (0.0000)	425.562 (0.0000
PP	NIV	cst	127.533 (0.0173)	129.502 (0.0129)	120.992 (0.0432)	393.925 (0.0000)	199.940 (0.0000)	190.619 (0.0000)
		cst & tend	89.7694 (0.6596)	130.830 (0.0105)	-13.8593 (0.0000)	242.81 (0.0000)	220.326 (0.0000)	282.938 (0.0000)
	1ère diff	cst	268.381 (0.0000)	333.340 (0.0000)	404.980 (0.0000)	266.275 (0.0000)	339.19 (0.0000)	668.660 (0.0000)
		cst & tend	264.836 (0.0000)	291.29 (0.0000	-18.3138 (0.0000)	223.505 (0.0000)	288.258 (0.0000)	677.479 (0.0000)

NB: If the p-value (values in brackets) are less than 0.01 ; 0.05 ; 0.10 it means that the variables are stationary at the 1%; 5% ; 10% levels respectively.

Source: Primary data analysis output

By performing the stationarity test of Levin, Lin and Chu; Im, Pesaran; Shin, ADF - Fisher Chi-square and PP - Fisher Chi-square, we found that GDP, SIZE and CAP series are stationary in level, while the NPLs, INF and RIR series are non-stationary or order (1) integrated (**see Table 2**).

Table 2. Stationarity of Islamic banks

			NPLs	INF	GDP	SIZE	CAP	RIR
LLC	NIV	cst	-8.9484 (0.0000)	-5.1307 (0.0000)	-7.23778 (0.0000)	-13.9106 (0.0000)	-28.93 (0.0000)	-8.01045 (0.0000)
		cst & tend	-13.2940 (0.0000)	-6.50634 (0.0000)	-12.0283 (0.0000)	-11.90 (0.0000)	-10.91 (0.0000)	-4.77657 (0.0000)
	1ère diff	cst	-15.3577 (0.0000)	-14.8351 (0.0000)	-18.203 (0.0000)	-12.8164 (0.0000)	-14.613 (0.0000)	-20.7179 (0.0000)
		cst & tend	-147.594 (0.0000)	-13.3603 (0.0000)	-14.578 (0.0000)	-43.6844 (0.0000)	-720.556 (0.0000)	-22.8978 (0.0000)
IPS	NIV	cst	-3.55922 (0.0002)	-2.54724 (0.0054)	-3.12823 (0.0009)	-6.39109 (0.0000)	-8.5300 (0.0000)	-4.16185 (0.0000)
		cst & tend	-0.81431 (0.2077)	-0.1334 (0.4469)	-2.92672 (0.0017)	-1.71716 (0.0430)	-1.831 (0.0335)	-0.47023 (0.3191)
	1ère diff	cst	-6.35110 (0.0000)	-7.134 (0.0000)	-9.7030 (0.0000)	-5.13071 (0.0000)	-8.780 (0.0000)	-13.1209 (0.0000)
		cst & tend	-3.76194 (0.0001)	-1.96194 (0.0249)	-2.51056 (0.0060)	-4.60207 (0.0000)	-4.1089 (0.0000)	-6.35789 (0.0000)
ADF	NIV	cst	82.5497 (0.0008)	68.141 (0.0449)	78.3261 (0.0064)	114.85 (0.0000)	122.67 (0.0000)	93.6683 (0.0002)
		cst & tend	60.1825 (0.0211)	42.693 (0.7587)	90.3533 (0.0004)	83.632 (0.0003)	79.537 (0.0008)	60.2988 (0.1510)
	1ère diff	cst	104.178 (0.0000)	145.07 (0.0000)	189.211 (0.0000)	111.69 (0.0000)	169.27 (0.0000)	238.350 (0.0000)
		cst & tend	83.6627 (0.0000)	86.0596 (0.0012)	108.164 (0.0000)	108.67 (0.0000)	135.44 (0.0000)	179.065 (0.0000)
PP	NIV	cst	86.6674 (0.0003)	67.5643 (0.0495)	69.9399 (0.0327)	214.407 (0.0000)	129.82 (0.0000	86.5632 (0.0010)
		cst & tend	78.621 (0.0003)	65.065 (0.0746)	107.465 (0.0000	115.71 (0.0000)	142.18 (0.0000)	104.227 (0.0000)
	1ère diff	cst	118.65 (0.0000)	191.78 (0.0000)	244.048 (0.0000)	119.453 (0.0000)	229.485 (0.0000)	326.717 (0.0000)
		cst & tend	129.974 (0.0000)	165.37 (0.0000)	172.243 (0.0000)	153.23 (0.0000)	230.599 (0.0000)	313.697 (0.0000)

Source: Primary data analysis output

3. 4. DESCRIPTIVE STATISTICS

Before presenting our econometric estimates, a descriptive analysis of credit risk and its independent variables as shown in Table 3

Table 3. Descriptive statistics

	N	Mean	Median	Standard deviation	JB		Shap-iro-Wilk (w)	Shap-iro-Francia
					Skewness	Kurtosis		
Panel A: conventional banks								
NPLs	470	5.6107	3.185	7.3108	0.0000	0.0000	0.59435 (0.0000)	0.59160 (0.00001)
					(0.0000)			
INF	528	5.8120	4.6	4.52138	0.0000	0.4813	0.94380 (0.0000)	0.94330 (0.00001)
					(0.0000)			
GDP	528	4.9787	4.6	4.4837	0.0000	0.0000	0.85249 (0.0000)	0.85033 (0.00001)
					(0.0000)			
SIZE	494	3.9887	4.0211	0.5686	0.5408	0.0000	0.97070 (0.0000)	0.97251 (0.00001)
					(0.0000)			
RIR	528	2.6926	2	8.6305	0.0000	0.0000	0.70906 (0.0000)	0.70697 (0.00001)
					(0.0000)			
CAP	486	14.3605	13.3836	5.3733	0.0000	0.0000	0.78454 (0.0000)	0.78169 (0.00001)
					(0.0000)			
Panel B: Islamic banks								
NPLs	190	6.4723	4.125	7.5414	0.0000	0.0000	0.7125 (0.0000)	0.7101 (0.00001)
					(0.0000)			
INF	264	4.7591	3.3	4.1310	0.0000	0.0752	0.9044 (0.0000)	0.9033 (0.00001)
					(0.0000)			
GDP	264	5.0575	4.6	4.8172	0.0000	0.0000	0.8664 (0.0000)	0.8625 (0.00001)
					(0.0000)			
SIZE	226	3.8625	3.8481	0.4749	0.9174	0.1945	0.9928 (0.3408)	0.9937 (0.40153)
					(0.4252)			
RIR	264	3.0409	1	10.2579	0.0000	0.0000	0.7709 (0.0000)	0.7681 (0.00001)
					(0.0000)			
CAP	223	14.741	13.3150	7.9412	0.0000	0.0000	0.8977 (0.0000)	0.8957 (0.00001)
					(0.0000)			

Source: Primary data analysis output

Table 4 below presents the estimation of correlation between the various variables used in our econometric model. The findings of the correlation matrix for conventional bank variables indicate a strong link between credit risk and GDP, CAP, and SIZE. These factors have a bad relationship with this risk. However, there is no causal correlation between the other factors (RIR and INF) and credit risk as shown in table 4.

In a similar vein, the findings from the correlation matrix for Islamic bank factors demonstrate a high association to credit risk, with the exception of GDP and CAP. These factors, however, showed a negative relationship with credit risk, whereas there is no correlation with the other variables.

Table 4. Correlation statistics

Panel A conventional banks					
	NPLS	INF	GDP	SIZE	RIR
NPLS	1.0000				
INF	0.1514*	1.0000			
GDP	-0.1564*	0.1311*	1.0000		
SIZE	-0.3562*	-0.4030*	-0.0442	1.0000	
RIR	-0.0426	-0.2421*	-0.2576*	0.0956*	1.0000
CAP	-0.0814	-0.0983*	-0.0117	-0.1640*	-0.0332
Panel B : Islamic banks					
	NPLS	INF	GDP	SIZE	RIR
NPLS	1.0000				
INF	0.1317	1.0000			
GDP	-0.2007*	0.1699*	1.0000		
SIZE	-0.1056	-0.1525*	-0.1318*	1.0000	
RIR	-0.0340	-0.2464*	-0.3075*	0.0757	1.0000
CAP	-0.3773*	-0.1806*	0.3245*	-0.3068*	-0.0428

** significance at 5%

Source: Primary data analysis output

4. RESULTS AND DISCUSSION

Based on the three selection criteria of Andrews and Lu's (2001) models, such as MBIC, MAIC and MQIC, the "order-1" liquidity risk model for Islamic and conventional banks is the most stable model, since it has the smallest MBIC, MAIC and MQIC. (**see table 5**). Indeed, to protect against loss of degrees of freedom, we have chosen the "order-1" credit risk model for Islamic banks, because the theory sets an order of 1 for a small sample size.

Table 5. PVAR's optimal moment and model **selection criteria**

lag	CD	J	J pvalue	MBIC	MAIC	MQIC
1	.9999991	161.8962	.0006112	-430.0128	-54.10383	-205.5677
2	.9999992	119.4896	.0003728	-275.1164	-24.51043	-125.4864
3	.9999144	51.39249	.046319	-145.9105	-20.60751	-71.09547

Source: Primary data analysis output

In **Table 6**, we report the coefficients of the PVAR model using the "GMM" method. We found a positive relationship between credit risk and its innovations, significant at the 5% level. We discovered a significant relationship at the 5% level between credit risk and solvency as well as a negative relationship between credit risk and real interest rate. This finding suggests that the credit risk of traditional banks is positively impacted by credit from the previous year, and negatively by the real interest rate and solvency.

Table 6. PVAR's estimates for conventional banks

	dNPLs	d INF	GDP	SIZE	RIR	CAP
d NPLs	0.0925676 (0.031)	-0.356801 (0.000)	-0.4874889 (0.000)	-0.003183 (0.000)	0.9695921 (0.000)	0.0586824 (0.000)
d INF	-0.041272 (0.195)	0.0379174 (0.152)	0.3751708 (0.000)	-0.0000333 (0.952)	-0.360798 (0.001)	0.0207276 (0.298)
GDP	-0.034989 (0.158)	-0.000050 (0.998)	0.1220883 (0.000)	-0.0002618 (0.527)	0.0275281 (0.726)	0.0107696 (0.432)
SIZE	-0.398547 (0.745)	-2.605846 (0.066)	-32.7261 (0.000)	0.9235336 (0.000)	80.20202 (0.000)	-2.328599 (0.011)
RIR	-0.044773 (0.001)	0.0806341 (0.000)	0.1437283 (0.000)	0.0003353 (0.164)	-0.149611 (0.004)	0.0138992 (0.088)
CAP	-0.219420 (0.007)	-0.164297 (0.007)	-0.7350125 (0.000)	0.0092982 (0.000)	0.0388805 (0.891)	0.475399 (0.000)

Source: Primary data analysis output

In **Table 7**, we report the coefficients of the PVAR model using the "GMM" method. During previous years, we saw a negative correlation between credit risk and credit risk, significant, between bank size and solvency, significant at the 5% level and between inflation rate and interest rate, significant at the 1% level. Indeed, we notice that the credit risk of Islamic banks is negatively affected by the credit risk of previous years, bank size, solvency, inflation rate and interest rate.

Table 7. PVAR's estimates for Islamic banks GMM

	dNPLs	dINF	GDP	SIZE	dRIR	CAP
dNPLs	-0.067164 (0.046)**	-0.029307 (0.000)***	-0.196895 (0.000)***	-0.0010937 (0.052)*	0.2469293 (0.000)***	0.1125992 (0.952)
dINF	-0.190557 (0.000)***	-0.153812 (0.000)***	-0.186142 (0.000)***	-0.0005815 (0.660)	1.115333 (0.000)***	-0.0137093 (0.521)
GDP	0.0129106 (0.617)	0.0536995 (0.000)	0.1216947 (0.000)	0.0018498 (0.010)	0.5218464 (0.000)	-0.0763905 (0.000)
SIZE	-4.035056 (0.026)**	4.687471 (0.000)***	-20.2557 (0.000)***	0.6877609 (0.000)***	91.91684 (0.000)***	5.72044 (0.000)***
dRIR	-0.027629 (0.000)***	-0.012518 (0.000)***	-0.040191 (0.000)***	0.0000262 (0.848)	-0.0955139 (0.000)***	-0.0107679 (0.027)**
CAP	-0.161501 (0.005)**	0.1382489 (0.000)***	-0.312514 (0.000)***	-0.0120595 (0.121)	1.13411 (0.000)***	1.109719 (0.000)***

Source: Primary data analysis output

Granger Wald's causality test results of the order-1 PVAR (**Table 8**) provide statistical evidence for the presence of a causal relationship between the variables. Indeed, we found that the causal relationship between interest rate and solvency are significant at the 5% level, i.e., interest rate and solvency explain the credit risk of conventional banks.

Table 8. PVAR's post-estimation tests for conventional banks

		chi2	df	Prob > chi2
d NPLs	d INF	1.679	1	(0.195)
	GDP	1.994	1	(0.158)
	SIZE	0.106	1	(0.745)
	RIR	10.309	1	(0.001)***
	CAP	7.354	1	(0.007)**
	All	50.591	5	(0.000)***
d INF	d NPLs	129.130	1	(0.000)
	GDP	0.000	1	(0.998)
	SIZE	3.381	1	(0.066)
	RIR	47.412	1	(0.000
	CAP	7.176	1	(0.007)
	All	203.610	5	(0.000)
GDP	d NPLs	83.279	1	(0.000)
	d INF	48.750	1	(0.000)
	SIZE	214.679	1	(0.000)
	RIR	20.539	1	(0.000)
	CAP	40.649	1	(0.000)
	All	284.958	5	(0.000)
SIZE	d NPLs	40.275	1	(0.000)
	d INF	0.004	1	(0.952)
	GDP	0.401	1	(0.527)
	RIR	1.934	1	(0.164)
	CAP	65.381	1	(0.000)
	All	144.084	5	(0.000)
RIR	d NPLs	49.509	1	(0.000)
	d INF	11.259	1	(0.001)
	GDP	0.123	1	(0.726)
	SIZE	250.436	1	(0.000)
	CAP	0.019	1	(0.891)
	All	570.452	5	(0.000)
CAP	d NPLs	12.905	1	(0.000)
	d INF	1.082	1	(0.298)
	GDP	0.616	1	(0.432)
	SIZE	6.387	1	(0.011)
	RIR	2.902	1	(0.088)
	All	34.243	5	(0.000)
All the eigenvalues lie inside the unit circle. PVAR satisfies stability condition.				
Eigenvalue stability condition				
Real	**Eigenvalue**	**Imaginary**		**Modulus**
	.9270012	0		.9270012
	.4513925	0		.4513925
	-.0468805	-.1609306		.16762
	-.0468805	.1609306		.16762
	.108631	-.0425859		.1166801
	.108631	.0425859		.1166801

Source: Primary data analysis output

Table 8. PVAR's post-estimation tests Panel VAR-Granger causality Wald test

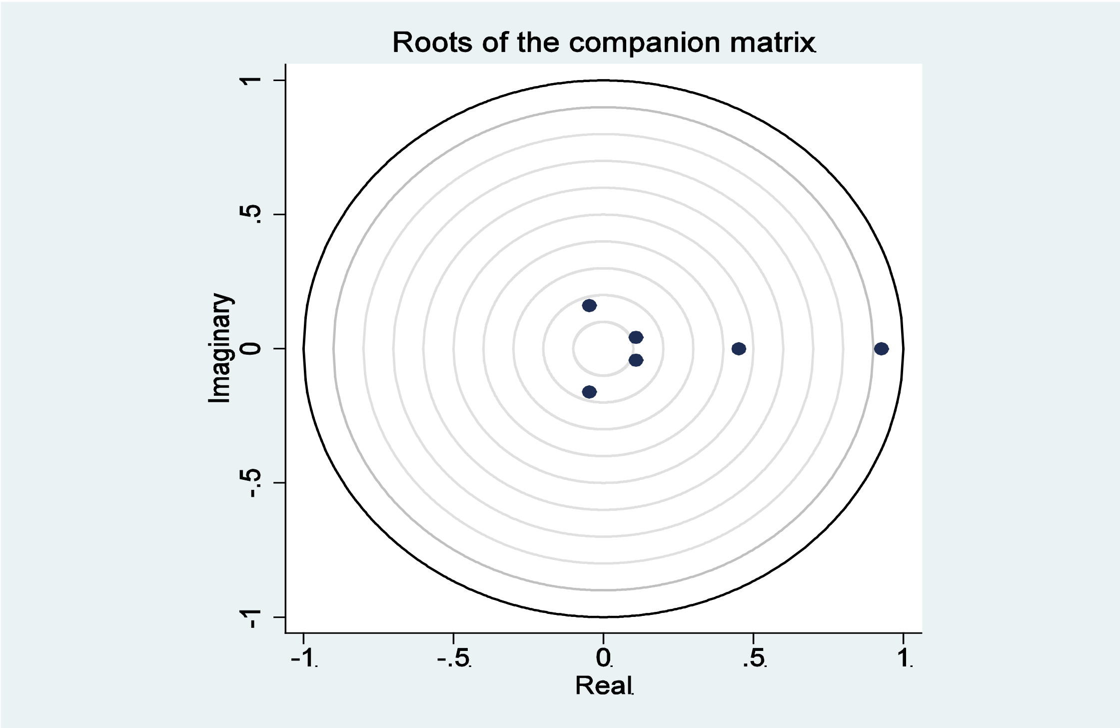
Ho: Excluded variable does not Granger-cause Equation variable

H1: Excluded variable Granger-causes Equation variable

The eigenvalues presented in table and figure 1 confirm that the PVAR model of credit risk for conventional banks is stable. The estimates are clearly less than 1. Thus, Figure No. 1 visually indicates that these eigenvalues are within the unity circle. Therefore, the stability condition of the VAR panel estimates is checked.

Figure 1 shows the eigenvalue stability condition of Non-performing loan ratio, inflation rate, GDP growth rate, bank size, real interest rate and solvency ratio for 48 conventional banks during 11 years from Bankscope and World Bank.

Figure 1. Eigenvalue in the unit circle for conventional banks



Source: Primary data analysis output

Figure 1 shows the eigenvalue stability condition of Non-performing loan ratio, inflation rate, GDP growth rate, bank size, real interest rate and solvency ratio for 48 conventional banks during 11 years from Bankscope and World Bank.

Granger Wald's causality test results of the order-1 PVAR (Table 9) provide statistical evidence for the presence of a causal relationship between the variables. In fact, we discovered that whereas bank size and solvency causal coefficients are significant at the 5% level, the causal coefficients of inflation rate and interest rate are significant at the 1% level. Indeed, inflation rate, interest rate, solvency and bank size explain the credit risk of Islamic banks.

Table 9. PVAR's post-estimation tests for islamic banks

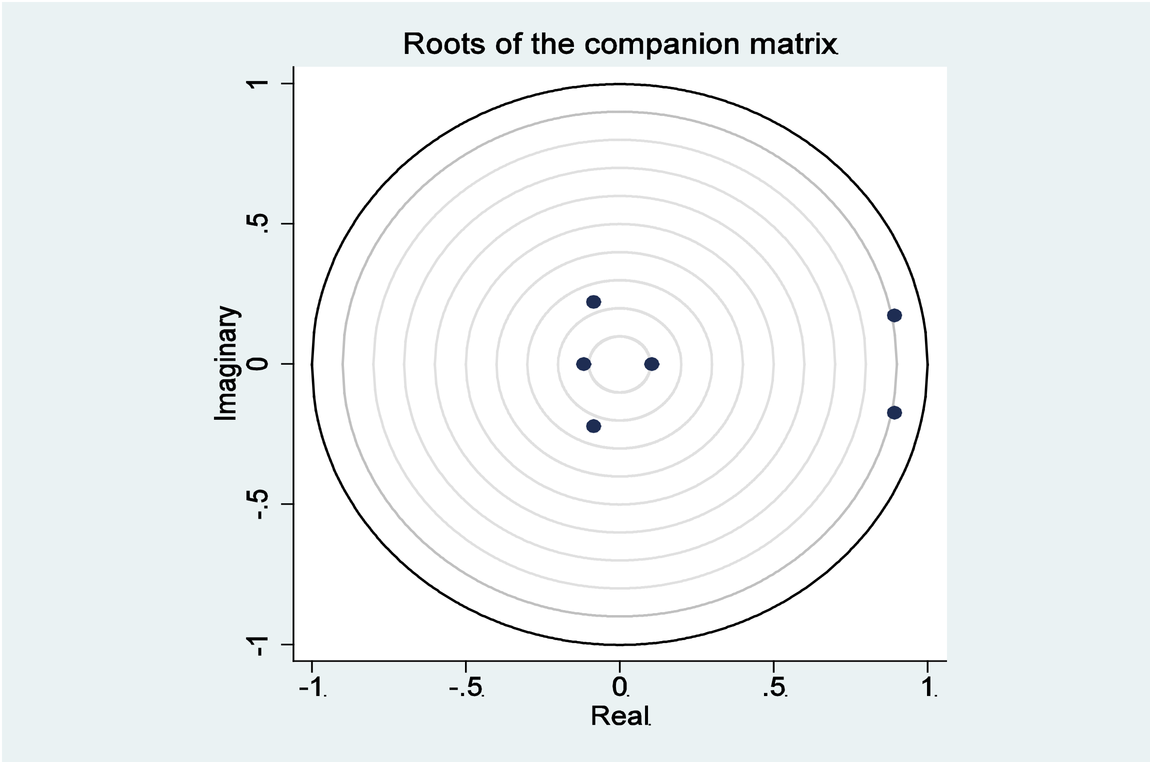
		chi2	df	Prob > chi2
d NPLs	d INF	45.083	1	(0.000)***
	GDP	0.250	1	(0.617)
	SIZE	4.929	1	(0.026)**
	dRIR	14.173	1	(0.000)***
	CAP	7.915	1	(0.005)**
	All	188.730	5	(0.000)***
d INF	d NPLs	14.511	1	(0.000)
	GDP	31.464	1	(0.000)
	SIZE	44.637	1	(0.000)
	dRIR	21.425	1	(0.000)
	CAP	12.759	1	(0.000)
	All	137.578	5	(0.000)
GDP	d NPLs	23.060	1	(0.000)
	d INF	20.225	1	(0.000)
	SIZE	241.943	1	(0.000)
	dRIR	17.370	1	(0.000)
	CAP	29.348	1	(0.000)
	All	632.944	5	(0.000)
SIZE	d NPLs	3.786	1	(0.052)
	d INF	0.194	1	(0.660)
	GDP	6.579	1	(0.010)
	dRIR	0.037	1	(0.848)
	CAP	2.401	1	(0.121)
	All	34.010	5	(0.000)
dRIR	d NPLs	12.981	1	(0.000)
	d INF	99.606	1	(0.000)
	GDP	41.932	1	(0.000)
	SIZE	360.656	1	(0.000)
	CAP	24.108	1	(0.000)
	All	1677.044	5	(0.000)
CAP	d NPLs	0.004	1	(0.952)
	d INF	0.412	1	(0.521)
	GDP	19.757	1	(0.000)
	SIZE	26.094	1	(0.000)
	dRIR	4.879	1	(0.027)
	All	57.818	5	(0.000)
All the eigenvalues lie inside the unit circle. PVAR satisfies stability condition.				
Eigenvalue stability condition				
Real	Eigenvalue	**Imaginary**		Modulus
	.8925202	.1734722		.9092221
	.8925202	-.1734722		.9092221
	-.084709	.2214848		.2371311
	-.084709	-.2214848		.2371311
	-.117027	0		.117027
	.1040885	0		.1040885

Source: Primary data analysis output

We use the variables: dnpls: Non-performing loan ratio. dinf: inflation rate. GDP : GDP growth rate. SIZE: bank size. RIR: real interest rate. CAP: solvency ratio.

The eigenvalues presented in table and figure 2 confirm that our VAR panel model of credit risk for Islamic banks is stable. The table shows that the estimates are clearly less than 1. Thus, Figure 2 visually indicates that these eigenvalues are within the unity circle. Therefore, the stability condition of the VAR panel estimates is checked.

Figure 2. Graph of eigenvalue in the unit circle for islamic banks



Source: Primary data analysis output

Figure 2 displays the liquidity risk eigenvalue stability condition, Non-performing loan ratio, inflation rate, GDP growth rate, bank size, real interest rate and for 24 islamic banks during 11 years from Bankscope and World Bank.

Looking into the results of variance decomposition (see **Table 10**), we notice that 97.21% of the change in conventional banks' credit risk is explained by itself, and only 0.94%, 0.86%, 0.78%, 0.14% and 0.04% of the change in credit risk is explained by solvency, bank size, real interest rate, GDP growth rate and inflation rate shocks, successively.

Table 10. FEVD: Forecast-error variance decomposition for conventional banks

Response variable And Forecast	horizon	dnpls Impulse	dinf	GDP	SIZE	RIR	CAP
dnpls	0	0	0	0	0	0	0
	1	1	0	0	0	0	0
	2	0.9721668	0.0004451	0.0014454	0.0086588	0.0078038	0.00948
	3	0.9700066	0.0004738	0.0014522	0.008678	0.0080613	0.0113281
	4	0.9692354	0.0004763	0.0015202	0.0087876	0.0080668	0.0119136
	5	0.9686258	0.000476	0.0016047	0.0089305	0.0080661	0.012297
	6	0.9681082	0.0004757	0.0016796	0.009065	0.0080645	0.0126069
	7	0.9676662	0.0004755	0.0017445	0.0091837	0.008063	0.0128671
	8	0.9672878	0.0004752	0.0018003	0.0092865	0.0080617	0.0130883
	9	0.9669633	0.000475	0.0018482	0.0093752	0.0080606	0.0132774
	10	0.966685	0.0004749	0.0018894	0.0094516	0.0080597	0.0134395
dinf	0	0	0	0	0	0	0
	1	0.008453	0.991547	0	0	0	0
	2	0.1363823	0.8167328	0.0003178	0.0012175	0.038351	0.0069984
	3	0.1356644	0.8111655	0.0004026	0.007448	0.0381801	0.0071393
	4	0.1359321	0.8069275	0.001047	0.0109527	0.037981	0.0071597
	5	0.1363976	0.8039336	0.0015558	0.0125418	0.0378538	0.0077173
	6	0.1365717	0.8015525	0.0019485	0.0135265	0.037755	0.0086458
	7	0.1366603	0.7995042	0.0022746	0.0142286	0.0376707	0.0096616
	8	0.1367126	0.7977358	0.0025491	0.0147722	0.0375985	0.0106319
	9	0.1367463	0.7962139	0.0027821	0.0152146	0.0375367	0.0115066
	10	0.1367706	0.7949066	0.0029808	0.015584	0.0374836	0.0122744
GDP	0	0	0	0	0	0	0
	1	0.000248	0.1244075	0.8753445	0	0	0
	2	0.0416866	0.1249983	0.7153949	0.0360281	0.0393075	0.0425846
	3	0.0406547	0.1189413	0.6871837	0.0374827	0.0392673	0.0764704
	4	0.0422487	0.1155178	0.6700522	0.0375512	0.0382226	0.0964075
	5	0.0431391	0.1133057	0.6591026	0.0388187	0.037603	0.1080309
	6	0.0442008	0.1116247	0.6509712	0.0406694	0.0371283	0.1154055
	7	0.0452783	0.110263	0.6444619	0.0425878	0.0367427	0.1206662
	8	0.0462561	0.109134	0.6390952	0.0443655	0.0364219	0.1247272
	9	0.0471114	0.1081875	0.6346081	0.0459356	0.0361523	0.128005
	10	0.0478478	0.1073893	0.6308287	0.0472931	0.0359246	0.1307165
SIZE	0	0	0	0	0	0	0
	1	0.0760789	0.00041	0.1182787	0.8052324	0	0
	2	0.1515874	0.0002724	0.128117	0.6789858	0.0006015	0.040436
	3	0.1661182	0.0002163	0.1303426	0.6034511	0.0014047	0.0984672
	4	0.1681508	0.0001791	0.1304708	0.5507932	0.0019672	0.1484389
	5	0.1674883	0.0001555	0.1300421	0.5133815	0.0023643	0.1865683
	6	0.1662933	0.0001397	0.129537	0.4864301	0.0026478	0.2149522
	7	0.1651525	0.0001284	0.1290906	0.4665989	0.0028549	0.2361747
	8	0.164196	0.0001201	0.1287256	0.4516775	0.0030102	0.2522706
	9	0.163423	0.0001138	0.1284339	0.440217	0.0031292	0.2646831
	10	0.1628033	0.0001089	0.1282011	0.431255	0.0032222	0.2744095

Response variable And Fore-cast	**horizon**	**dnpls Impulse**	**dinf**	**GDP**	**SIZE**	**RIR**	**CAP**
RIR	0	0	0	0	0	0	0
	1	0.0307534	0.0713638	0.0164208	0.0670999	0.814362	0
	2	0.0681725	0.0550394	0.0283881	0.2439895	0.6043695	0.0000409
	3	0.085736	0.0491576	0.0426521	0.2741243	0.5400361	0.0082937
	4	0.0960801	0.0457727	0.0492851	0.2786145	0.5030038	0.0272439
	5	0.1001415	0.0433145	0.0536055	0.2792477	0.4762369	0.047454
	6	0.1028058	0.0413861	0.0568521	0.2784376	0.4552559	0.0652625
	7	0.104727	0.0398523	0.0593679	0.2772675	0.4385748	0.0802105
	8	0.1061778	0.0386188	0.0613634	0.2761251	0.4251605	0.0925545
	9	0.1073196	0.0376166	0.0629733	0.2751153	0.4142632	0.1027121
	10	0.1082405	0.0367954	0.0642879	0.2742543	0.4053338	0.1110881
CAP	0	0	0	0	0	0	0
	1	0.0015285	0.0001158	0.0038124	0.3507082	0.0013957	0.6424394
	2	0.0181749	0.0003176	0.0066896	0.3668159	0.0019801	0.6060219
	3	0.0251124	0.0003382	0.0079447	0.3721284	0.001952	0.5925242
	4	0.0275177	0.0003418	0.0086404	0.3746083	0.0019302	0.5869616
	5	0.0285623	0.0003415	0.0091164	0.3755703	0.0019266	0.5844829
	6	0.0291452	0.0003408	0.0094769	0.3758021	0.0019298	0.5833053
	7	0.0295291	0.00034	0.009765	0.3757333	0.0019352	0.5826975
	8	0.0298122	0.0003393	0.0100029	0.3755589	0.0019409	0.5823459
	9	0.0300363	0.0003388	0.0102029	0.3753603	0.0019462	0.5821156
	10	0.0302207	0.0003383	0.0103726	0.3751694	0.001951	0.581948

Source: Primary data analysis output

Looking into the results of variance decomposition (see **Table 11**), we notice that 98.59% of the change in credit risk of Islamic banks is explained by itself, and only 0.58%, 0.32%, 0.24%, 0.24%, 0.21% and 0.02% of the change in credit risk is explained by inflation rate, solvency, GDP growth rate, real interest rate and bank size shocks, successively.

Table 11. FEVD: Forecast-error variance decomposition for islamic banks

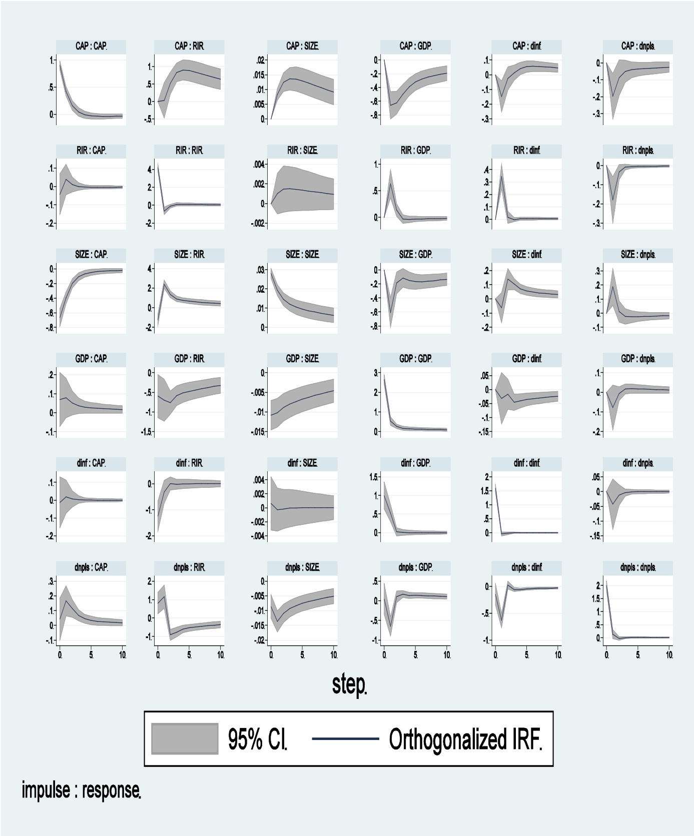
Response variable And Fore-cast	horizon	dnpls Impulse	dinf	GDP	SIZE	dRIR	CAP
	0	0	0	0	0	0	0
	1	1	0	0	0	0	0
	2	0.985906	0.005871	0.0024366	0.000289	0.00219	0.0032
	3	0.980304	0.0059016	0.0024552	0.000853	0.003073	0.0074
	4	0.978436	0.0058877	0.0025212	0.001354	0.003169	0.0086
dnpls	5	0.977387	0.0058927	0.0025295	0.002053	0.003181	0.0089
	6	0.976477	0.0058881	0.0025373	0.002946	0.003180	0.0089
	7	0.975428	0.0058816	0.0025883	0.003904	0.003179	0.0090
	8	0.974097	0.0058754	0.0026953	0.004836	0.003190	0.0093
	9	0.972492	0.0058708	0.0028537	0.005672	0.003218	0.0098
	10	0.970712	0.0058682	0.0030462	0.006366	0.003262	0.0107
	0	0	0	0	0	0	0
	1	0.021002	0.9789976	0	0	0	0
	2	0.029646	0.9339151	0.0097242	0.000897	0.009135	0.0166
	3	0.030845	0.9295444	0.0010772	0.000973	0.009141	0.0187
	4	0.03078	0.9274898	0.011028	0.000971	0.009177	0.0205
dinf	5	0.030835	0.9261448	0.0110897	0.001036	0.009250	0.0216
	6	0.03088	0.9254241	0.011115	0.001177	0.009275	0.0221
	7	0.030915	0.925014	0.0111144	0.001399	0.009282	0.0222
	8	0.030934	0.9247062	0.011112	0.001681	0.009280	0.0222
	9	0.030940	0.9243805	0.0111219	0.001993	0.009277	0.0222
	10	0.030934	0.9239794	0.0111495	0.002304	0.009277	0.0223
	0	0	0	0	0	0	0
	1	0.005429	0.0269467	0.9676239	0	0	0
	2	0.05145	0.0323054	0.8664137	0.023218	0.006422	0.0201
	3	0.051431	0.0302155	0.8031638	0.082699	0.007601	0.0248
	4	0.052323	0.02825	0.7519677	0.135778	0.00710	0.0245
GDP	5	0.049710	0.0262187	0.7015805	0.179456	0.007311	0.035
	6	0.045983	0.0242601	0.6513228	0.21022	0.008185	0.0600
	7	0.042081	0.0225363	0.6045365	0.227723	0.009653	0.0934
	8	0.038627	0.0211178	0.5638919	0.234731	0.011413	0.1302
	9	0.035900	0.0200179	0.5304751	0.23475	0.013191	0.1656
	10	0.033936	0.0192031	0.504146	0.230856	0.014819	0.1970

Response variable And Fore-cast	horizon	dnpls Impulse	dinf	GDP	SIZE	dRIR	CAP
SIZE	0	0	0	0	0	0	0
	1	0.019602	0.0008742	0.0051565	0.974366	0	0
	2	0.022642	0.0006387	0.0348948	0.884056	0.002532	0.0552
	3	0.017105	0.0011848	0.0562691	0.776587	0.007282	0.1415
	4	0.012088	0.0019463	0.0711574	0.676303	0.012207	0.2262
	5	0.008931	0.0027022	0.0812492	0.592093	0.016507	0.2985
	6	0.007283	0.0033702	0.0879727	0.524509	0.020045	0.3568
	7	0.006664	0.0039311	0.0923867	0.471419	0.022874	0.4027
	8	0.006705	0.0043893	0.0952068	0.430339	0.025095	0.4382
	9	0.007147	0.0047548	0.096913	0.399113	0.026805	0.4652
	10	0.007816	0.0050385	0.0978356	0.376003	0.028086	0.4852
dRIR	0	0	0	0	0	0	0
	1	0.025310	9.93	0.1461971	0.017717	0.810765	0
	2	0.020966	0.0454493	0.143622	0.092509	0.673420	0.0240
	3	0.036948	0.0441983	0.1366116	0.144102	0.616186	0.0219
	4	0.036091	0.0414044	0.1309584	0.183131	0.577938	0.0304
	5	0.033784	0.0384594	0.1281031	0.213087	0.536354	0.0502
	6	0.031211	0.0357437	0.1263038	0.231093	0.495889	0.0797
	7	0.028797	0.0333717	0.1250915	0.238947	0.459800	0.1139
	8	0.026852	0.0314317	0.1243059	0.239778	0.429535	0.1480
	9	0.025454	0.0299246	0.1237414	0.236449	0.405399	0.1790
	10	0.024563	0.0288004	0.1232824	0.231181	0.386938	0.2052
CAP	0	0	0	0	0	0	0
	1	0.000462	0.007612	0.0504717	0.452334	0.01903	0.4700
	2	0.000966	0.0062053	0.0746668	0.391537	0.027531	0.499
	3	0.001160	0.0060128	0.0884301	0.346420	0.02959	0.5283
	4	0.001764	0.0062647	0.0949799	0.309240	0.031514	0.5562
	5	0.002747	0.006507	0.0984247	0.279375	0.033167	0.5797
	6	0.0039	0.0067381	0.1002835	0.25596	0.034476	0.5986
	7	0.005109	0.0069385	0.1011591	0.238159	0.03548	0.6131
	8	0.00629	0.0070992	0.1014084	0.225279	0.036234	0.6236
	9	0.007392	0.0072184	0.1012634	0.216688	0.036744	0.6306
	10	0.008351	0.0072977	0.1008902	0.211741	0.037050	0.6346

Source: Primary data analysis output

Figure 3 presents the impulse responses for the entire sample of conventional banks (49). The most important responses of the credit risk of conventional banks are against credit risk in previous years, inflation rate, GDP growth rate, real interest rate, bank size and solvency shocks.

Figure 3. Impulse-Response for the Panel Vector Autoregression using the PVAR approach for conventional banks



Source: Primary data analysis output

The vector autoregressive panel's impulse response is seen in **Figure 3**. The variables are; credit risk (NPLs), inflation rate (INF), GDP growth rate (GDP), real interest rate (RIR), bank size (SIZE) and solvency (CAP).

- *Credit risk shock:* The IRF graph shows that the effect of the credit risk shock has an immediate positive impact on the future credit risk for traditional banks, with a downward trend. This implies that future non-performing loans (t) have been influenced by the shocks of non-performing loans in the previous year (t-1), then the credit risk variable is explained by itself.
- *Inflation rate shock:* The inflation rate shock has negative effects on the credit risk of conventional banks, in the short term, then it returns back and is cancelled until the end of the period, i.e. the volume of non-performing loans can be reduced after an increase in the inflation rate shock.
- *GDP growth rate shock:* Similarly, the GDP growth rate shock leads to a reduction in the credit risk of conventional banks, but in the short term with a magnitude of 1, then it returns back and is cancelled until the end of the period. We note that the shock of a higher GDP growth rate may lead to a future decline in non-performing loans.
- *Bank size shock:* It should be recognized that the short-term impact of the bank size shock on conventional banks' credit risk is positive, then its response becomes negative, and finally it is cancelled out for the rest of the period, i.e. a shock of increasing bank

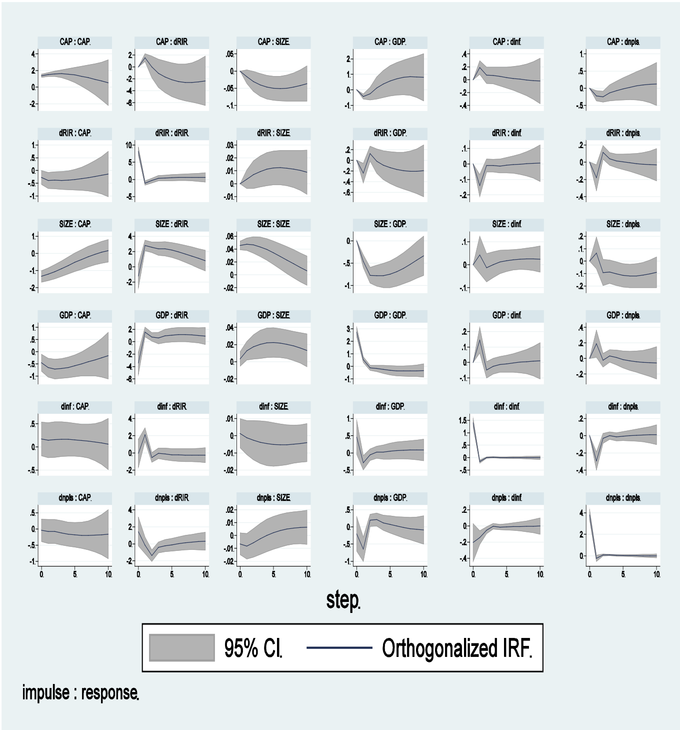
size (t) reduces the volume of future non-performing loans (t+2).

- *Solvency shock:* The solvency shock has a negative impact with a magnitude of 2 on the credit risk of conventional banks in the short-term, and then it will tend to increase until it is cancelled out for the rest of the period. This may indicate that the shock of a decrease in solvency at a given moment increases the volume of future non-performing loans.
- *Real interest rate shock:* Additionally, the real interest rate shock has a significant impact on the traditional banks' lending risk at the beginning of the period, but it begins to cancel out in the same year until the end of the period. It should also be noted that the shock of an increase in interest rates (t) reduces credit risk in the following year (t+1).

Figure 4 presents the impulse responses for the entire sample of Islamic banks (26).

The most important responses of the credit risk of Islamic banks are against credit risk in previous years, inflation rate, GDP growth rate, real interest rate, bank size and solvency shocks.

Figure 4. Impulse-Response for the Panel Vector Autoregression using the PVAR approach for islamic banks



Source: Primary data analysis output

This figure displays the panel's vector autoregressive impulse response. The variables are; credit risk (NPLs), inflation rate (INF), GDP growth rate (GDP), real interest rate (RIR), bank size (SIZE) and solvency (CAP).

Figure 4 displays the panel's vector autoregressive impulse response. The variables are; credit risk (NPLs), inflation rate (INF), GDP growth rate (GDP), real interest rate (RIR), bank size (SIZE) and solvency (CAP).

- *Credit risk shock:* The future credit risk of Islamic banks reacts instantly and positively to a credit risk shock throughout the period. The credit risk's reaction begins to reverse from the first year to the end of the period. We notice that credit risk is explained by itself with a positive sign.

- *Inflation rate shock:* Throughout the period, the inflation shock has a detrimental impact on the credit risk of Islamic institutions. The effect begins to cancel out after the first year until the end of the period. We notice that the shock of rising inflation reduces the volume of future non-performing loans.
- *GDP growth rate shock:* At the beginning of the term, credit risk responds positively to a shock in the GDP growth rate. then becomes negative after the second year. This implies that the shock of an increase in the GDP growth rate may reduce the volume of non-performing loans after the second year.
- *Bank size shock:* The response of credit risk to a bank size shock only began in the first year. It is positive with a downward trend from the second year till the end of the period. This contributes to the fact that the shock of an increase in bank size starts to reduce the volume of future non-performing loans from the second year onwards.
- *Solvency shock:* We notice that the impact of a solvency shock on the credit risk of Islamic banks is negative with a slight upward trend from the sixth year onwards, i.e. the solvency shock reduces the volume of non-performing loans in the future.
- *Real interest rate shock:* A shock of actual interest rates has a negative impact on the credit risk of Islamic banks in the first year and then a positive effect until the fifth year.

We conclude that the shock of an increase in the real interest rate increases credit risk from the third year onwards. By performing *the stationarity test* (Section 3) for Islamic and conventional banks , we found that GDP, SIZE and CAP series are stationary in level, it means that their mean and variance remain constant over time. While the NPLs, INF and RIR series are non-stationary or order (1) integrated, it suggests that these series may exhibit trends or have systematic patterns that evolve over time.

The findings of the *correlation matrix* for Islamic and conventional bank variables indicate a strong link between credit risk and Real interest rate, Bank Size and Inflation rate. This suggests that the level of credit risk may vary depending on whether real interest rates rise or fall. The relationship between bank size and credit risk may suggest that bigger banks are more or less vulnerable to credit risk. This is a result of the borrowers that larger banks serve or the diversification of their portfolios. The relationship between credit risk and inflation rate implies that both high inflation and credit risk may be correlated. Inflation can have an impact on borrowers' capacity to repay loans.

In this study, we found that a positive GDP growth rate shock leads to a negative credit risk response by Islamic and conventional banks. Positive GDP growth indicates a generally positive state of the economy. Both Islamic and conventional banks may experience a decrease in credit risk as a result of better economic conditions having a beneficial effect on borrowers' credit quality. This observation is in accord with Louzis et al (2010), Castro (2013), Chaibi and Ftiti (2015), and Darwez et al. (2023). A decrease in bank size shock increases the volume of future non-performing loans in Islamic and conventional banks. Larger banks frequently have portfolios that are more diversified, which helps reduce risk. Reduced diversification brought on by a smaller bank may increase the bank's vulnerability to particular or sector-specific risks, which would raise the number of non-performing loans (NPLs). These results are consistent with those of Salsa and Saurina (2002) and Louzis, D et al. (2012). Solvency decreases shock at a moment (t-2) increases the volume of non-performing loans in the future (t) of Islamic and conventional banks. So, the impact of a solvency shock on the credit risk is negative. Sufficient capital reduces credit risk by strengthening the bank's resilience to unfavorable economic conditions and acting as a buffer against unforeseen losses. This is consistent with the finding of Makri et al. (2014) and Chaibi and Ftiti (2015). Real interest rates increase shock increases the credit risk of Islamic banks from the third year onwards. Increased real interest rates have the potential to cause a decline in economic activity, which could impact both individual and corporate creditworthiness. Islamic banks may have trouble controlling the credit risk connected to their financing operations if the economy worsens as a result of rising interest rates. This result is comparable to that of Abid et al (2014) and Roland et al (2013). However, a real interest rate shock negatively affects the credit risk of conventional banks. Conventional banks may see an increase in interest income as a result of higher real interest rates. By improving the credit risk profile and acting as protection against credit losses, this could raise the banking industry's overall profitability.

Stress tests are an essential tool for improving bank transparency because they offer a thorough evaluation of a bank's ability to withstand unfavorable economic conditions and possible financial shocks. Stress tests are a useful tool for identifying and evaluating the different risks that a bank might encounter in the event of recession. Stress scenarios are applied to the bank's portfolio to provide stakeholders and regulators with information about possible weaknesses.

5. CONCLUSIONS

Stress testing is an important component of the Basel II Accord in the area of risk management because it can help financial institutions better understand the effect of stress scenarios and measure their exposure to risk under extreme conditions. This would allow them to manage these risks through corrective action.

In this paper, we used the Abrigo and Love's (2015) Vector Autoregressive Panel methodology as a direct measure of bank fragility to study the contribution of stress tests to reduce banking opacity and improve financial resistance to adverse shocks. This approach is able to detect the magnitude of the effect of shocks over a given period by using the impulse response function (IRF) analysis and variance decomposition (FEVD). It tests the resistance of credit risk to adverse shocks. We conducted stress tests of credit risk against macroeconomic and specific shocks over a sample of 75 conventional and Islamic listed banks in 7 MENA countries. According to our knowledge, this is the first that the PVAR approach has been used to solve this issue.

The stress test consists in selecting the scenarios that define exogenous shocks, then analyzing and discussing its results to give a partial picture of risk-taking by financial institutions. Finally, the publication of these results may raise awareness of these institutions about the different risks because the market may interpret this information negatively.

The results of the impulse response functions provide statistically significant evidence on the strong effect of the different macroeconomic and specific shocks on the credit risks of conventional and Islamic banks in the MENA region. As a result, our findings indicate that there are few significant differences between Islamic and conventional banks in terms of how they respond to extreme shocks in terms of credit risk. However, these results provide information on the resistance of the tested banks to the different studied shocks.

We conclude that the results of stress tests are associated with significant changes (positive or negative) in credit risk. In addition, our results confirm that most macroeconomic and specific determinants are in fact early warnings for shock prediction. This shows evidence that stress tests produce information about credit risk exposure and about the real conditions of financial institutions. Which reduce the opacity bank.

By simulating loss distributions in financial institution portfolios, it appears that these tests evaluate the consequences of growing fragility on the macroeconomic environment and on the financial system's long-term stability. Therefore, more transparency on bank losses and risks would have also enabled bank regulators to focus more attention on financial institutions and react early to take "corrective measures" through the recapitalization of failing or insolvent banks.

Similarly, our results show that it is possible to integrate modern banking activities such as stress testing into studying Islamic banks. Therefore, our study may be of interest to international investors and portfolio managers since the publication of information on the resistance of the tested banks against adverse shocks may change their expectations. Otherwise, Stress tests are incredibly important when it comes to evaluating how well a bank can handle situations. By conducting these tests policymakers can pinpoint any weaknesses, in the banking system. Take steps to improve overall financial stability. The significance of stress tests doesn't just stop there. They also help refine frameworks and enhance transparency in the banking industry. Policymakers should view stress tests as a tool, for assessing and managing risks ultimately leading to an more transparent financial system.

Further research can explore the impact of stress tests on improving the stock performance of conventional banks in regions outside of the MENA countries during the Covid 19 crisis.

ACKNOWLEDGMENT

'This work was supported through the Annual Funding track by the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia [Project No GRANT 5565]

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ECONOMICS
Innovative and Economics Research Journal
Volume 12, No. 1, 2024
www.economicsrs.com

IMPROVING ENVIRONMENTAL PERFORMANCE THROUGH INNOVATIVE ACADEMIC CITIZENSHIP BEHAVIOUR: GREEN TRAINING AND DEVELOPMENT, GREEN RECRUITMENT AND SELECTION AS ANTECEDENTS IN JORDANIAN GOVERNMENT UNIVERSITY

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Received 13.12.2023. | Sent to review 23.12.2023. | Accepted 02.04.2024.

Original article

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JEL Classification: J50, J53, J59

Doi: 10.2478/eoik-2024-0002

UDK: 005.74:[339.923:351.756(569.5)

ABSTRACT

Education institutions are thought to be largely responsible for environmental pollution even though businesses of all shapes and sizes contribute to this issue. This research explores how important factors might help government universities in Jordan develop and implement green innovation. It seeks also to examine whether the academic citizenship behaviour is a mediating variable that explains the connection between green training and development, green recruitment and selection, and organization environmental performance. Accordingly, an email survey was conducted to collect responses from 404 employees in the Jordanian Government universities. The study used contemporary variance-based structural equation modelling (Amos-SEM) for data analysis and hypothesis testing. The obtained results indicated a positive association between green training and development and two variables, namely academic citizenship behaviour, and organization environmental performance. They also indicated a positive association between green recruitment and selection and two variables, namely, academic citizenship behaviour and organization environmental performance. As well as between academic citizenship behaviour and organization environmental performance. Furthermore, they showed mediating effects of academic citizenship behaviour in the relationship between green training and development and organization environmental performance and between green recruitment and selection and organization environmental performance. This paper helps to provide insights to HRM practitioners, shedding light on the importance of Green HRM practices and their role in enhancing organization environmental performance.

Keywords: *Green innovation, Green human resource management practices, green training and development, green recruitment and selection, academic citizenship behaviour, and organization environmental performance*

1. INTRODUCTION

Due to the COVID-19 pandemic, there have been considerable modifications made to how organization staff members perform, utilizing teleworking techniques and a significant amount of weekday flexibility (Almaiah et al., 2022a, b; Alsyouf et al., 2023; Lutfi et al., 2022a; Saad et al., 2022). Environmental sustainability is now crucial in both society and businesses (Lutfi et al., 2023). Concerning issues now include climate change, natural disasters, and the loss of natural resources (Markey et al., 2019; Shakeyev et al., 2023). The management of modern firms places a strong emphasis on maximizing the health and happiness of their workforce, hence enhancing environmental sustainability is crucial (Darwez et al., 2023). This comprises guaranteeing the pressure from the governments, stakeholders, customers, employees, and competitors, according to (Almaiah et al., 2023; Almaiah et al., 2022c; Alshirah et al., 2022; Mishra & Rath, 2021). The ecosystem is currently in a dire situation as a result of excessive tree cutting, fossil fuel burning, and carbon monoxide emissions brought on by an organization (Alrfai et al., 2023). Fawehinmi et al., (2020) stated that AGENDA 2030 is an international initiative that calls on world leaders, particularly those in developing nations, to establish objectives for reducing pollution and improving the environment.

According to Renwick et al. (2013), GHRM is a policy, practice, and system that strives to improve employees' environmental, business, and individual priorities while also encouraging them to contribute to society's and the environment's well-being. Through GHRM's particular procedures, one can ascertain whether a company is aligned with environmental protection (Liu et al., 2023). Additionally, it emphasizes the ecosystem's fragility and how the organization's economic actions affect the environment (Mishra et al. 2014). Tang et al., (2018) mentioned that Green HRM adds to the wellness of the organization's internal and external stakeholders in addition to enhancing overall performance.

By fostering a culture of sustainability and overseeing sustainability projects, GHRM provides a source of competitive advantage (Dluhopolskyi et al., 2022; Sroufe et al., 2010). According to Jabbour et al. (2013), organizations can implement environmental strategies and goals by integrating organizational learning, performance reviews, job descriptions, training, recruiting, teamwork, selection, and organizational culture. Practitioners and academics from all over the world are drawn to GHRM. It alludes to procedures used by businesses to enhance environmental performance by emphasizing the human component of environmental management (Alqudah et al, 2021; Lutfi et al., 2022b; Roscoe et al., 2019). According to Sharma and Gupta (2015), GHRM is still a relatively new phenomena in many countries, particularly in organizations, despite gaining a position in the literature and seeing a growth in its use in many organizations as a treatment for environmental degradation (Almaiah et al., 2022d; Jabbour et al., 2013). Based on this background information, the conference paper's main focus is on the fundamental strategies for raising awareness among HR managers and staff about GHRM, resource utilization, and the green movement in order to support organizations' efforts to preserve and protect the natural environment for sustainable growth and the protection of employees' and customers' health and safety (Shishakly et al., 2024; Prasetyo & Kistanti, 2023; Alqudah et al, 2021).

Employee green behavior is crucial for the environmental management system's successful implementation. Employee involvement, according to studies, is essential for an organization's EMS to be successful (Almaiah et al., 2022e; Mazzi et al., 2016). Employee green behavior (EGB) also enables a company to improve its environmental performance and gain a competitive edge (Alshebami et al., 2023; Kim et al., 2019).

2. OBJECTIVE OF THIS STUDY

This research aims to measure the academic citizenship behavior effect between green training and development, green recruitment and selection on organization environmental performance.

1. To measure the effect of green training and development on organization environmental performance.
2. To measure the effect of green recruitment and selection on organization environmental performance.

3. To measure the effect of green training and development on academic citizenship behavior.
4. To measure the effect of green recruitment and selection on academic citizenship behavior.
5. To measure the effect of academic citizenship behavior on organization environmental performance.
6. To measure the academic citizenship behavior that mediates the effect between green training and development on organization environmental performance.
7. To measure the academic citizenship behavior that mediates the effect between green recruitment and selection on organization environmental performance.

3. SIGNIFICANCE OF THIS STUDY

This study sheds light on a new concept that has not been searched in detail in developing countries, especially Jordan. The critical investigation of the relationship between GHRM, academic citizenship behavior, and organization environmental performance is expected to benefit the government, especially the Ministry of Higher Education & Scientific Research, policy makers, Government Universities, and academic lecturers.

The Ministry of Higher Education & Scientific Research will help the government develop related policies to ensure that the green HRM practices are suitable for adoption in the Jordanian context. This research also benefits policymakers in implementing an environmental management system from the view of the environmental impact.

University's president can use the guidelines provided by the government to improve and incorporate more responsible green HRM practices in their daily practices to ensure that the organization's environment is protected. Academic lecturers can also improve the image of their university by the requirements of a conscientious community to avoid any negative impact on the environment.

Demonstrating a commitment to environmental sustainability is crucial in the face of global environmental challenges. By incorporating green practices in academic citizenship behavior, universities contribute to reducing their ecological footprint and promoting responsible environmental stewardship. This study can emphasize the integration of sustainability principles into the core of higher education. By focusing on academic citizenship behavior, green training, and recruitment, the study may recognizes the pivotal role that universities play in promoting environmental awareness and responsibility.

This study can inclusion of green training and development underscores the importance of equipping faculty, staff, and students with the knowledge and skills needed to adopt sustainable practices. This holistic approach recognizes that environmental awareness is an ongoing learning process.

This study examines the current state of GHRM practice and suggests solutions for companies interested in the field. A conceptual model that provides these companies with a plan to adopt GHRM practices provides these solutions. This study better identifies HRMS practices or practices that may be most appropriate for an organizational environmental performance. Therefore, from this study, universities understand the efforts to adopt and implement the first practices that have the most significant impact on the organizational environmental performance (OEP) dependent variable. Ultimately, for companies that have already implemented GHRM practices, this study will guide improving sustainability goals.

At the end of the study, there will be some recommendations for future research; This opens up new research areas related to GHRM and green governance in Jordan that can be applied. In addition, the GHRM best practice model for green activity can be tested regardless of the type of organization and the context of the country.

4. SCOPE OF THE STUDY

The scope of this study includes investigating the academic citizenship behavior effect between green human resource practices on organization environmental performance. Only the academic lecturers in the Government Universities will participate in the survey. Huselid and Becker (2000) and Neal, West, and Patterson (2004) recommended that the sample include participants with the best knowledge of department operations and the subject matter. These academic lecturers. They typically acquire formal knowledge in this field from the university or take HRM courses and training to manage personnel.

The objective of the data collection process is to test the hypotheses on how different aspects of green HRM practices can drive organizational environmental performance. The result of the tests is limited to the specific sample of academic lecturers of Government Universities in Jordan.

5. LITERATURE REVIEW

5. 1. GREEN HUMAN RESOURCE MANAGEMENT

The definition of green HRM has only been provided by a small number of scientists in the literature. Green HRM, as defined by Renwick et al. (2008), is the incorporation of corporate environmental management within HRM. For coordinating personnel with the organization's environmental strategy, these experts highlighted a number of employment, performance management and evaluation policies, training and development, labor relations, and pay and reward policies as effective tools. 2013 saw a swift redefinition of green HRM by these scholars as an element of environmental management. Jabbour, Santos, and Nagano (2010) claim that "green HRM" entails "greening" operational aspects of HRM such job analysis, job description, recruiting, selection, training, performance evaluation, and reward. Green HRM was characterized by Jabbour (2011) as the extent of green HRM practices in relation to the functional and competitive aspects of HRM. These definitions do not materially differ from one another or are contradictory. As a result, the researcher has put out a precise definition of "green human resource management" based on the meaning of these concepts. It is possible to define green human resource management as the environmental (green) direction of all HRM practices or operations at all organizational levels.

In order to address the needs of environmental sustainability, green human resource management focuses on the fundamental ideas of human resource management as well as its objectives, aims, functions, operations, activities, and strategies. In order to benefit the individual, society, the environment, and company, green human resource management refers to policies, procedures, and systems that make an organization's employees ecologically friendly (Arulrajah & Opatha, 2016). This is the combination of conventional human resource management with environmental management (Bombiak & Kluska, 2018). In order to further sustainability, green HRM incorporates human resource management principles. It can also cover strategies and regulations that help people, businesses, and the environment by developing a green workforce. GHRM is viewed as a more comprehensive corporate social responsibility framework. Human resource management functions including hiring, selecting, training, and developing employees, as well as incentive systems and personnel management systems that are effective instruments for connecting workers to corporate environmental strategy, were established by Renwick et al. (2013). Many researchers have agreed on implementing training, communication with the environment, organizational training, and environmental management programs. (Sammalisto & Brorson, 2008; Triana & Ortolano, 2005).

Studies on green human resource management have been conducted in a number of industries, including manufacturing (Yusliza et al., 2019; Dumont et al., 2017; Chaudhary, 2020; Saeed et al., 2019), healthcare (Saeed et al., 2019; Jia et al., 2018), and information technology (Ojo and Raman, 2019). But there haven't been many studies on how to get higher education institutions to embrace environmental sustainability programs using green human resource management (Gilal et al., 2019). According to Hooi et al. (2012), talent and human resource management are crucial to the success of university greening. Galal et al.'s (2019) emphasis that green behavior should be integrated into higher education's environmental management processes is evidence that this is a good idea, as it fosters staff activism and improves the institution's economic and environmental efficiency. Therefore, if higher education institutions want to fulfill their goals for green governance, it is advised that they implement green human resource management techniques. Amin et al. (2014) relating to how human resource management techniques help ensure that higher education staff members perform in line with the strategic goals of the institution.

Recent green HRM study places more emphasis on personal results. According to Ojo and Raman (2019), current empirical research has focused on environmental HRM in terms of environmental behavior, attitudes, and indicators, environmental loyalty, and environmental performance. (Pham, Tuukova, & Phan, 2019) studied worker performance, such as environmental staff behavior. Chaudhary (2019) mentions organizational commitment (Kim et al., 2019), psychological capital to protect the environment (Saeed et al., 2019), and green climate psychology (Dumont et al., 2016) as well as EGB for employees who mediate. However, there is still much to learn about how green HRM affects employee behavior (Yong, Yusliza, & Fawehinmi, 2019). To understand the crucial mechanisms between green HRM and EGB, such as environmental knowledge, study is required in addition to additional research (Ren et al., 2018).

5. 2. GREEN RECRUITMENT AND SELECTION

All human resource management activities are built around recruitment and selection processes. None of the other functions will perform effectively without the appropriate personnel utilizing the appropriate techniques (Tomková, 2016). There are discrepancies between the recruiting process's two steps, recruitment and selection (Oaya, Ogbu, & Remilekun, 2017). Searching for and choosing potential employees for employment in companies is known as recruitment; it is the process of choosing the best candidates from a pool of applicants (Singh et al., 2020).

Green employment is an ongoing process and recruiting new talents who are familiar with ecosystems and who are well versed in environmental protection. Green noted that recruiting new talent familiar with ecosystems and ecosystems supports effective environmental management in organizations (Stringer, 2009). Hiring quality employees is a crucial issue in the war for talent, and even firms realize that being an entrepreneur is an efficient method to attract fresh talent. The most inventive and creative employees in the competition boost the employment organization. Renwick et al. (2013); Stringer (2009).

Green recruitment and selection refer to the procedures for hiring people with behaviors, knowledge, and skills in an organization's environmental management system. Applications for green jobs and competitions are offered through online tools such as email, online application forms, or a global talent pool. Telephone or video conversations are conducted to minimize travel-related environmental impacts (Saini & Shukla, 2016). Since recruitment is aimed at attracting potential candidates to apply for existing vacancies in internal and external organizations, it is important to not only have the skills and knowledge to protect the environment, but also to protect the environment. can be used as a platform to attract interested employees. Attracting candidates with green turns makes it easier for companies to hire professionals who are familiar with sustainable processes and fundamentals, such as recycling, storage, and creating a smart world (Sanyal, 2017).

Prachi Sharma (2011) argues that greener hiring is a free hiring process to reduce the impact of paper on the environment. Recruitment is usually done through online tools such as websites, emails, online application forms, and other applications. Is it possible to have a conversation by phone or video call?

Catherine (2016) conducted a study on the effectiveness of green employment practices in human resource managers in the IT sector. Research has shown that establishing strong recruitment practices can help attract and retain good employees. Investing in employees creates a way to make long-term profits. The corporate world is slowly embracing sustainability by applying green hiring and selection practices. The human resources department has a primary responsibility to ensure that organizations understand and accept green practices and can sell the concept.

5. 3. GREEN TRAINING AND DEVELOPMENT

Green education is conducted to form environmentally conscious behavior of employees in the workplace. It focuses on training green skills, training waste management staff, and raising awareness of the green environment (Roy & Therin, 2008). The importance of green training is to empower employees to manage the environment, teach them energy-efficient methods at work, reduce waste, raise organizational environmental awareness, and engage employees in solving environmental problems. (Zoogah, 2011).

In order to evaluate the effects of green employment, training, development, and learning on business outcomes in Pakistan, Bhutto and Auranzeb (2016) conducted a study. The investigation came to the following conclusions: Many workers like environmentally friendly companies, and those who work there report high levels of engagement and job satisfaction. Research additionally shows that green practices need to be carefully monitored and that without green human resource practices, firms cannot attain sustainability and environmental performance. The College of Technology and Logistics Management's Okechukwu (2017) work focuses on the influence, growth, and productivity of staff members. The findings indicated a link between green training, commercial success, and job happiness. Both offered a useful and motivating road map for the growth of the company and its personnel. The study discovered that education and development initiatives elevated work satisfaction in education.

5. 4. ACADEMIC CITIZENSHIP BEHAVIOR

According to Yong, Yusliza, and Fawehinmi (2019), research on how green HRM affects employee behavior is still in its infancy. It should be researched in additional organizational contexts, such as higher education. In addition, additional study should be done to identify the key interactions between green human resource management and employee civic engagement, including environmental awareness (Ren et al., 2018).

Green behavior is the conduct of those who value the environment the most. Researchers with a keen interest in environmental sustainability, such as Ones and Dilchert (2012a), have recently drawn attention to the necessity of promoting environmentally friendly behavior (EGB) in the workplace.

EGBs are what Ones and Dilchert (2012) referred to as quantifiable employee behaviors that support environmental sustainability goals at work. EGB, according to Block and Wagner (2014), is the behavior of employees who consciously try to lessen the influence of their conduct on the environment through better paper use, reducing electricity waste, and properly recycling goods at work. Organizations will support the successful implementation of the EGB organizational environmental management system and encourage the organization to increase its environmental efficiency. Dumont et al. (2017) noted that green behavior could be green behaviors in a role or an additional role. Both forms of behavior are different but similar and contribute to the organization's environmental performance. Green role-playing behaviors are the actions required to complete a standard form.

The link between green human resource management and the ECB has been studied in previous studies (Dumont et al., 2016; Kim et al., 2019; Saeed et al., 2019), but scholars have paid less attention to staff performance. Employee behavior among green people Resource practices and environmental efficiency of the organization, especially in higher education. The environmental impact on green human resource management practices has not been sufficiently emphasized (Ren et al., 2018). Pinzone et al., (2019) mentioned that some claim that even after the implementation of green human resource management techniques, staff members still lack the necessary skills to engage in and abstain from ecologically harmful actions. This means that effective implementation of green human resource management solutions is required to influence employees' intrinsic talent, motivation, and performance. Green training (GT) recipients have a better understanding of environmental issues and potential solutions (Pinzone et al., 2019).

The recruitment and motivation of employees focused on organizational goals, such as environmental sustainability initiatives, are influenced by green human resource management, according to studies (Mishra, 2017). This is so that employees may understand what is expected of them when firms support environmental sustainability. The advantages they stand to gain from it, which complement their dedication to putting EGB into practice by aiding sustainability projects, spur on motivation.

5. 5. ORGANIZATION ENVIRONMENTAL PERFORMANCE

Environmental efficiency is the company's activity in creating a green environment. Environmental performance is an essential step for the success of a company's core business. What is called environmental efficiency, or environmental efficiency in general, is the measurable outcome of an environmental management system related to aspects of environmental management. Assessing environmental efficiency based on environmental policy, environmental goals, and environmental objectives (Ikhsan, 2008).

An organization's efficacy can be characterized as the outcome of all of its operations. It can be evaluated by comparing the efficiency and efficacy of its current behavior (Ghosh & Mukherjee, 2006). According to the resource-based theory (Ghosh & Mukherjee, 2006), synergy can be produced by managing a company's resources in a way that promotes positive efficiency and helps it become the market leader. The degree to which companies engage in environmentally friendly activities is an indicator of environmental efficiency that reduces the negative impact of production processes on the environment (Wong et al., 2013). The environmental efficiency of an organization is the practice of initiatives in such a situation that has a positive impact on the environment. Therefore, to benefit from environmental protection, companies are encouraged to use effective methods of environmental management (Jackson & Seo, 2010). Numerous studies have been done that show how different green human resource management methods significantly and favorably affect organizational and environmental performance. Green human resource management practices such as green employment, green education, and green awards can enhance and support an organization's environmental performance and create a competitive advantage (Mandip, 2012; Paille et al., 2014; Ahmad, 2015; Renwick et al., 2013; Masri & et al.; Roy & Xastagir, 2016).

6. PREVIOUS STUDIES

6. 1. GHRM AND ORGANIZATIONAL ENVIRONMENTAL PERFORMANCE

A study on organizational environmental performance in Jordanian health service organizations was undertaken by Rawashdeh (2018). In Jordanian health care companies, this study investigates the connection between green human resource management (HRM) strategies, such as green recruiting and selection, green training and development, and environmental performance. The findings demonstrate a moderate adoption of green human resource management in Jordanian hospitals; the recruitment and selection processes had the strongest link, and training and development had the smallest correlation. Additionally, a statistically significant correlation between the three HRM practices and environmental performance was found. This study, which is said to be the first of its kind in Jordan, examined how environmental performance may be provided through human resource functions in hospitals and other health service organizations. It supports the body of literature on environmental preservation and green human resource management, which is underdeveloped in developing nations like Jordan. The study suggests that greater sample sizes should be sought after. Additionally, research that involves a variety of collaborating industries is more valuable (Rawashdeh, 2018).

According to Renwick et al. (2013), the hiring procedure would be environmentally friendly. The organization's environmental performance will increase with the hiring of additional personnel with environmental protection experience. According to Al-Rawashdah (2018), green employment and choice have a significant positive impact on an organization's environmental performance. Green workplace training techniques for staff training and development can improve environmental performance and address current environmental issues by reducing waste, using enough resources, conserving energy, and reducing environmental deterioration (Zoogah, 2011).

According to the studies, the researcher showed a positive and significant effect between green training and development, green recruitment and selection, and organization environmental performance, supporting the (H1, H2).

H1: Green training and development are positively effect on organization environmental performance.

H2: Green recruitment and selection are positively effect on organization's environmental performance.

6. 2. GHRM AND ACADEMIC CITIZENSHIP BEHAVIOR

The research conducted by Yong et al. (2019) highlighted questions about the relationship between knowledge acquisition and employee behavior in human resource management techniques. This study aims to investigate the effects of green human resource management (green HRM) on green employee behavior (EGB) by educating professors at public research universities in Malaysia about environmental issues. The results of the study demonstrate that general environmental literacy mediates the effect of green HRM on EGB. This finding has theoretical implications for the concepts of motivation, ability, and ability (Yong et al., 2019).

Dumont, Shane, and Ding (2016) conducted a study evolving concept, green HRM (Green Human Resource Management) is conceptualized to influence the green behavior of workers in the workplace. The results showed that green HRM, directly and indirectly, influences green behaviors in the role but indirectly influences green behavior with additional roles mediated by the psychological green climate. Individual green values mitigated the effect of psychological green time on additional green behaviors. Still, they did not reduce the effect of green HRM or psychological green time on green role behaviors. These findings suggest that green human resource management influences the behavior of green employees in the workplace in additional jobs and roles; However, this happens through a variety of social and psychological processes. The recommendations of this research are to explore employee nongreen attitudinal and behavioral outcomes of green HRM. Such research will make greater contributions to the HRM literature on the effect of HRM on employee workplace outcomes (Dumont, Shen & Deng, 2016).

Researchers have previously examined the relationship between GHRM and the ECB (Saeed et al., 2019; Dumont et al., 2016; Kim et al., 2019), but they haven't given much attention to green human resource management. They increased the potential and environmental impact of mediation. The significance of the company's environmental metrics in terms of the EGB-HRM link, particularly in the higher education sector. The effect of the environment on green human resource management strategies has not received enough attention (Ren et al., 2018). Some claim that even after the implementation of green human resource management techniques, staff members still lack the necessary skills to engage in and abstain from ecologically harmful actions. This means that in order to affect employees' innate talent, motivation, and performance, green human resource management strategies must be efficiently adopted. Employees that receive green training (GT) are more informed about environmental problems and solutions (Khassawneh, 2014; Pinzone et al., 2019).

According to the studies, the researcher showed a positive and significant effect between green training and development, green recruitment and selection, and academic citizenship behavior, supporting the hypothesis (H3, H4) and sub hypothesis.

H3: Green training and development are positively effect on academic citizenship behavior.

H4: Green recruitment and selection are positively effect on academic citizenship behavior.

6. 3. ACADEMIC CITIZENSHIP BEHAVIOR ON ORGANIZATION ENVIRONMENTAL PERFORMANCE

Wiernik, Dilchert, and Deniz (2016) conducted the study under the title Age and Employee Green Behaviors effect on environmental performance A Meta-Analysis. The researchers meta-analyzed 132 independent correlations and 336 d-values based on 4676 professional employees from 22 samples in 11 countries to assess how such age disparities are evident. Contrary to common belief, pro-environmental actions and age revealed marginally favorable associations, suggesting that older persons exhibited these activities at work a little more frequently. The pro-environmental behaviors of conserving resources, avoiding harm, and taking initiative all showed relationships with age that looked to be linear overall; however, non-linear patterns were seen for the behaviors of changing oneself and influencing others. Because employees have a strong sense of responsibility for the environment, he demonstrates in his research that green conduct among employees in a firm has a good impact on environmental performance (Dilchert, Deniz, & Wiernik 2016).

EGB is a quantifiable employee behavior that supports workplace environmental sustainability goals, according to Ones and Dilchert (2012). EGB was defined by Block et al. (2014) as the behaviors of employees who consciously aim to reduce the detrimental effects of their behavior on the environment through better paper use, reducing electricity waste, and properly recycling goods in the workplace. Organizations will urge the organization to improve its environmental efficiency and support the effective application of the EGB organizational environmental management system.

According to the studies, the researcher showed a positive and significant effect between academic citizenship behavior and organization environmental performance, supporting the hypothesis (H5).

H5: Academic citizenship behavior at Government Universities are positively effect on organization environmental performance.

6. 4. ACADEMIC CITIZENSHIP BEHAVIOR THAT'S MEDIATES THE AFFECT BETWEEN GREEN HUMAN RESOURCE PRACTICES ON ORGANIZATION ENVIRONMENTAL PERFORMANCE

Al Kerdawy (2019) Green human resource management practices and employee behavior in an environmental organization: an interactive impact of green emotions. In order to better understand the relationship between green human resource management (GHRM) and public organizational behavior for the environment (OCBE), this study will examine the potential mediation role of green emotions. This study's methodology is based on a constructive view of quantitative research methodology. The idea was tested using empirical measurements and statistical techniques. In order to assess the mediating function of green emotions between GHRM and OCBE, the study makes use of the most recent literature. The study projected reciprocal changes and looked at the connections between factors including GP, OCBE, and GHRM. To measure quantitative data, SPSS was employed. This study reveals that OCBE and green passion are positively impacted by GHRM. Additionally, it was discovered that the association between GHRM and OCBE was considerably mediated by the green feeling.

Another study by Mayangsari and Nawangsari (2019) uses the behavior of green employees as a mediating variable. This study aims to analyze the impact of green employment and teach the environmental impact on the behavior of green employees as an intermediary variable. The methodology of this study is a quantitative approach, as it relates more to measurement and sampling methods. This study was conducted at PT Wira Cipta Perkasa, and the use of probabilistic selection and selection methods is a simple random sampling method. For a total sample of 100 people, data analysis methods in this study used Modeling of Structural Equations (SEM) using PLS (partially the smallest squares) as software. This study showed that green employment, green training, and green employee behavior have a positive and significant impact on environmental behavior. Recommendations of this study: 1) The recruitment process described in PT Wira Cipta Perkasa does not have a complete recruitment system through the internet, so it needs a recruitment process. It will be easier for management to select employees who have applied for the job. 2) Include candidates in the recruitment process who understand the environment and include environmental standards in the job description. 3) To increase the interest of employees in scientific development, it is necessary to improve the training system as its application to allow knowledge to be easily acquired anywhere. Their knowledge of the environment is also essential to improving the company's environmental performance. 4) Create a work culture that loves the environment so that employees have a sense of caring for the work-related environment. Therefore, a new green culture will appear in PT Wira Cipta Perkasa. 5) Create a corporate social responsibility program in the company to raise employees 'awareness of the environment and implement environmental measures (Mayan sari & Nawangsari, 2019).

Several researchers have found a positive relationship and effect between GHRM and Environmental organizational performance and employee citizenship behaviors (Al Kerdawy, 2019; Mayangsari & Nawangsari, 2019; Vidović & Ritan, 2022; Yong et al., 2019).

According to the studies, the researcher showed that academic citizenship behavior positively affects green human resource practices on organization environmental performance and supports the hypothesis (H6, H7).

H6: Academic citizenship behavior effect positively between green training and development on organization environmental performance.

H7: Academic citizenship behavior effect positively between green recruitment and selection on organization environmental performance.

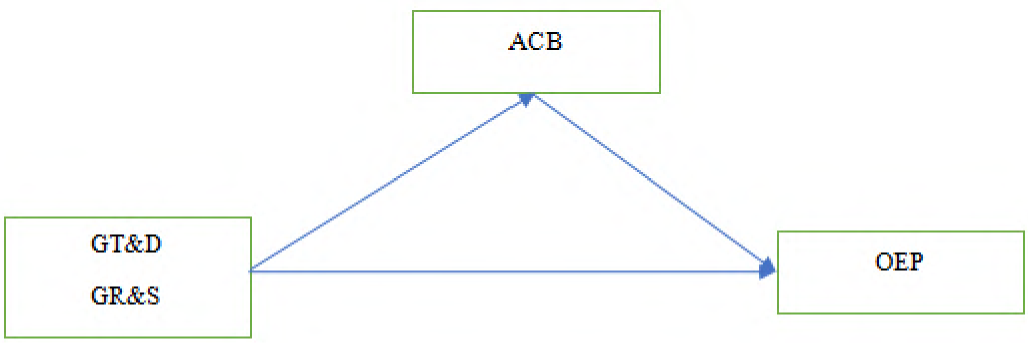
7. STUDY MODEL

Smyth (2004) claims that the research framework is built on concepts and theories that aid in problem identification and the development of research questions for pertinent literature. The interaction of dependent, independent, and mediating variables is part of a study framework. An independent variable is the one that the researcher manipulates to change or effect the dependent variable, whereas a dependent variable is the data that the researcher measures, monitors, or predicts that is anticipated to be changed by the independent variable. The relationship (observed) between an independent variable and its dependent variable is explained by the mediating variable.

Specifically, four variables must be examined based on the study topic entitled "the academic citizenship behavior effect between green human resource practices on organization environmental performance in the government universities in Jordan."

two of the four variables are independent variables. The dependent variable is organizational environmental performance; it relies on the following independent variables that affect organizational environmental performance (Figure 1): green recruitment and selection, and green training and development. The mediating variable is academic citizenship behavior.

Figure 1. Study Model



Source: By Authors

8. RESEARCH METHODOLOGY

8. 1. METHODS AND INSTRUMENTS

For the purpose of this research, a quantitative survey study was adopted, and SEM was used in the analysis process. The respondents of this paper are academician in Jordanian government universities, which consisted of ten universities (The Hashemite University, The University of Jordan, AL-Hussein Bin Talal University, Yarmouk University, Mutah University, Tafila Technical University, Jordan University of Science & Technology, Al albayt University, AL-Balqa Applied University, and German Jordanian University).

8. 2. SAMPLE AND PROCEDURES

A self-administrated questionnaire was adopted to gather data from academicians in Jordanian Government universities. The Universities were contacted and informed about the objective of this research. A convenient sampling technique has been used in the current study. The final version was then sent by e-mail to the heads of HR departments, which was forwarded to the permanent academicians in their universities. A 10-point Likert scale from “strongly disagree” (1) to “strongly agree” (10) was used to measure all items. As many as 450 employees were approached to fill in the questionnaire. A total of 420 responses were received after the end of the survey, and 16 responses were found uncompleted, so, the final sample of this study is 404 participants. Details of participants’ profiles are shown in table (1).

Table 1. Demographics Profile

Variable		Frequency	Percentage%
Gender	Males	343	84.9%
	Females	61	15.1%
Marital Status	Single	100	24.8%
	Married	298	73.8%
	Others	6	1.5%
Age	20-29	15	3.7%
	30-39	102	25.2%
	40-49	133	32.9%
	50-59	145	35.9%
	60 and above	9	2.2%
Experience	0-5	18	4.5%
	6-10	189	46.8%
	11-15	166	41.1%
	15-20	20	5%
	20 and above	11	2.7%
Educational qualification	Master	35	8.7%
	PhD	369	91.3%
Academic rank	Lecturer	35	8.7%
	Assistant Prof	189	46.8%
	Assoc. Prof	136	33.7%
	Prof	44	10.9%
Total		404	100%

Source: SPSS

9. DATA ANALYSIS AND RESULTS

9. 1. CONFIRMATORY FACTOR ANALYSIS (CFA)

Confirmatory Factor Analysis (CFA) refers to the validation procedure through the measurement model. The usage of CFA is important for ensuring that the instrument used is suitable for the current research (Harrington, 2009). This type of analysis requires the number of components, which items reflect the component, and the correlation between the components (Alrawad et al., 2023a; Thompson, 2004). This procedure was performed before utilizing Structural Equation Modelling (SEM) for all the latent constructs (Alrawad et al., 2023b; Shih-I, 2011; Awang, 2011, 2012, 2014, 2015). However, Thompson (2004) claimed that research without theories cannot be conducted on this type of factor analysis because the analysis tested is directly based on the theory and the degree of model fit, which can be measured in several different ways. According to Chua (2009), Confirmatory Factor Analysis (CFA) is used to validate convergent and discriminant validity after Exploratory Factor Analysis (EFA).

There are two ways of conducting CFA: Individual CFA or Pooled CFA. This study used Pooled CFA because it is easier and better than the Individual CFA, since it runs all the latent variables simultaneously; in addition, it can save time, is more efficient and is highly recommended (Chong, Nazim, & Ahmad, 2014; Awang, 2011, 2012, 2014, 2015). The degree of freedom will rise by mixing constructs (Awang 2011; 2012; 2014; 2015), and Pooled CFA was also used to avoid the identification problem when the construct contains fewer than four elements (Muhamad Safiih & Nor Azreen, 2016; Nazim & Ahmad, 2013; Jöreskog, 1978). According to Wang, French, and Clay (2015), the reflective measurement model should include at least three indicators for each component.

9. 1. 1. VALIDITY

In the measurement model, three types of validity need to be examined – construct validity, convergent validity and discriminant validity – all of which have different functions, and need to be achieved before proceeding with structural equation modelling (Henseler, Ringle, & Sarstedt, 2014; Ringle, Sarstedt, & Straub, 2012; Lehmann, 1988).

9. 1. 1. 1. Construct validity

Construct validity refers to the extent that the observed items represent the latent construct (Hair et al., 2010). This means it is related to the accuracy of measurement. Through confirmatory factor analysis, the validity of the construct can be seen through matching the fit indices including the chi-square ($\chi 2$), normed chi-square, χ 2/df ($3.0 \leq \chi 2/df \leq 5.0$) (Schumacker & Lomax, 2004) and the goodness of fit. All the fit indices can be categorized under three groups; namely, absolute fit, incremental fit and parsimonious fit (Awang, 2011, 2012, 2014, 2015).

Fitness indexes that fall under absolute fit include chi-square ($\chi 2$), goodness-of-fit index (GFI), and Root-Mean-Square Error of Approximation (RMSEA). Garson (2011), Hair et al. (2010), Bentler and Bonett (1980), Hooper, Coughlan and Mullen (2008), and Lu, Lai, and Cheng (2007) suggested that the value for GFI should be above 0.9. According to Kenny (2015), Hair et al. (2010), Blunch (2008), and Browne & Cudeck (1993), the value of RMSEA should be below 0.8, while Byrne (2010), Meyers, Gamst, & Guarino (2006) and Maccallum, Browne, & Sugawara (1996), suggested that below 1.0 was adequate for further analysis.

The incremental fit consists of several fit indexes, such as comparative fit index (CFI), normed fit index (NFI), incremental fit index (IFI) and Tucker-Lewis coefficient (TLI). Garson (2011), Hair et al. (2010), Hooper et al. (2008), Lu et al. (2007), and Browne & Cudeck (1993) proposed that the accepted value for CFI is above 0.9. However, values approaching 1 are considered to be an acceptable fit (Groenland & Stalpers, 2012; Suhr, 2008; Moss, 2016a). Hair et al. (2010), Kenny (2015), and Garson (2011) claimed that the accepted value for NFI is above 0.9, while Bentler & Bonett (1980) proposed values of 0.95 and above are best for NFI. The accepted value for IFI is 0.90 and above (Bentler & Bonett, 1980; Bentler, 1990; Garson, 2011). However, Kenny (2015) suggested that values approach 1 are acceptable for IFI. Meanwhile, values for TLI above 0.90 are considered adequate for further analysis (Kenny, 2015; Hair et al., 2010; Tucker & Lewis, 1973).

PNFI and PCFI are classified under parsimonious fit. According to Meyers et al. (2006), values of 0.5 and below are acceptable for further analysis. Additionally, Chisq/df is also included under parsimonious fit. According to Hair et al. (2010), at least one fitness index should be selected in each category. This study used all the indexes as a key requirement of the SEM model was accepted and further analyzed empirically (Kline, 2010; Wahid, Ahmad, & Abdul Kader, 2010).

9. 1. 1. 2. Convergent validity

Convergent validity refers to the evaluation of the relationship between the latent variable and the items, to ensure they correspond with one another (Wang, French, & Clay, 2015; Smith & Li, 2010). According to Hair et al. (2010), there are several methods relating to Convergent Validity, one of which is the loading factor, for which standardized loading estimates should be 0.5 and above.

In addition, it can be evaluated by examining the Average Variance Extracted (AVE) for each construct (Awang, 2011, 2012, 2014, 2015; Hair et al., 2010). To achieve the Convergent Validity, the value of AVE should be equal to or more than 0.5 (Awang, 2011, 2012, 2014, 2015; Hair et al., 2010). Besides that, Convergent Validity can also be evaluated using the Critical Ratios (CR) of items (Smith & Li, 2010). If the value of CR is greater than 1.96 (significance level 0.05), it would be significant (Arbuckle, 2007).

9. 1. 1. 3. Discriminant validity

Discriminant Validity refers to the assessment of the differentiates between the latent variable and the other latent variables (Wang, French, & Clay, 2015; Shih-I, 2011; Smith & Li, 2010; Hair et al., 2010). According to Awang (2015), there are two requirements for ensuring that validity is achieved: the measurement model does not have any redundant items and the correlation between exogenous variables does not exceed 0.85. To fulfil this requirement, Average Variance Extracted (AVE) for every construct should be compared with its squared correlation in the model (Henseler et al., 2014).

9. 1. 2. RELIABILITY

To verify the reliability of the instrument for construct Green human resource management practices, Academic citizenship behavior, and Organizational environmental performance in this study, an instrument reliability analysis was conducted. There are three criteria for assessing reliability; namely, Factor loading, Composite Reliability, and Average Variance Extracted.

Since this research used AMOS to develop Structural Equation Modelling, for this reliability analysis, the researcher used Composite Reliability (CR) and Average Variance Extracted (AVE). Values for the Composite Reliability (CR) above 0.6 are considered achieved while values for the Average Variance Extracted (AVE) above 0.5 are considered achieved (Awang, 2015). In addition, Construct Reliability (CR) is also typically taken into consideration. Hair et al. (2010) suggested that reliability values of 0.7 and above are considered to show good reliability; however, it is acceptable if the value is between 0.6 and 0.7.

Table 2 showed that the fitness indexes assessment for the measurement model.

Table 2. The Fitness Indexes assessment for the measurement model

Model Fit Indices	Value	Recommended value	Comments
X^2 /df	2.197	> 5.00	The required level is achieved
Comparative fit index (CFI)	0.938	< 0.90	The required level is achieved
Root Mean Squared Error of Approximation (RMSEA)	0.054	> 0.080	The required level is achieved
Goodness-of-Fit (GFI)	0.902	< 0.90	The required level is achieved
Tucker–Lewis index (TLI)	0.932	< 0.90	The required level is achieved

Source: By Authors

The value of Average Variance Extracted (AVE) and Composite Reliability (CR) must be evaluated once the Fitness Indexes have been accepted in order to determine the Convergent Validity and reliability. While CR has a lower minimum value of 0.6 than AVE, AVE has a lower minimum value of 0.5. The findings demonstrate that every concept and item included in the measuring model met the necessary value. This indicates that all of the model's components in Figure 4.2 were approved for future investigation. Table 3 provides a summary of the AVE and CR values for all the dimension's elements.

Table 3. CFA Results for the Measurement Model for all the Items in the Sub-Constructs

Variable	Item	Factor loading	AVE	Composite reliability
Green Training and Development	GTD1	.782	0.592	0.945
	GTD2	.780		
	GTD3	.748		
	GTD4	.935		
	GTD5	.717		
	GTD6	.727		
	GTD7	.689		
	GTD8	.935		
	GTD9	.789		
	GTD10	.712		
	GTD11	.651		
	GTD12	.713		
Green Recruitment and Selection	GRS1	.898	0.575	0.923
	GRS2	.829		
	GRS3	.695		
	GRS4	.828		
	GRS5	.758		
	GRS6	.716		
	GRS7	.641		
	GRS8	.692		
	GRS9	.732		
Academic citizenship behavior	ACB1	.792	0.653	0.928
	ACB2	.829		
	ACB3	.942		
	ACB4	.870		
	ACB5	.914		
	ACB7	.626		
	ACB9	.622		
Organization Environmental Performance	OEP1	.789	0.575	0.936
	OEP2	.605		
	OEP3	.742		
	OEP4	.614		
	OEP5	.778		
	OEP6	.809		
	OEP7	.749		
	OEP8	.868		
	OEP10	.858		
	OEP11	.602		
	OEP12	.859		

Source: By Authors (Data Analysis Results)

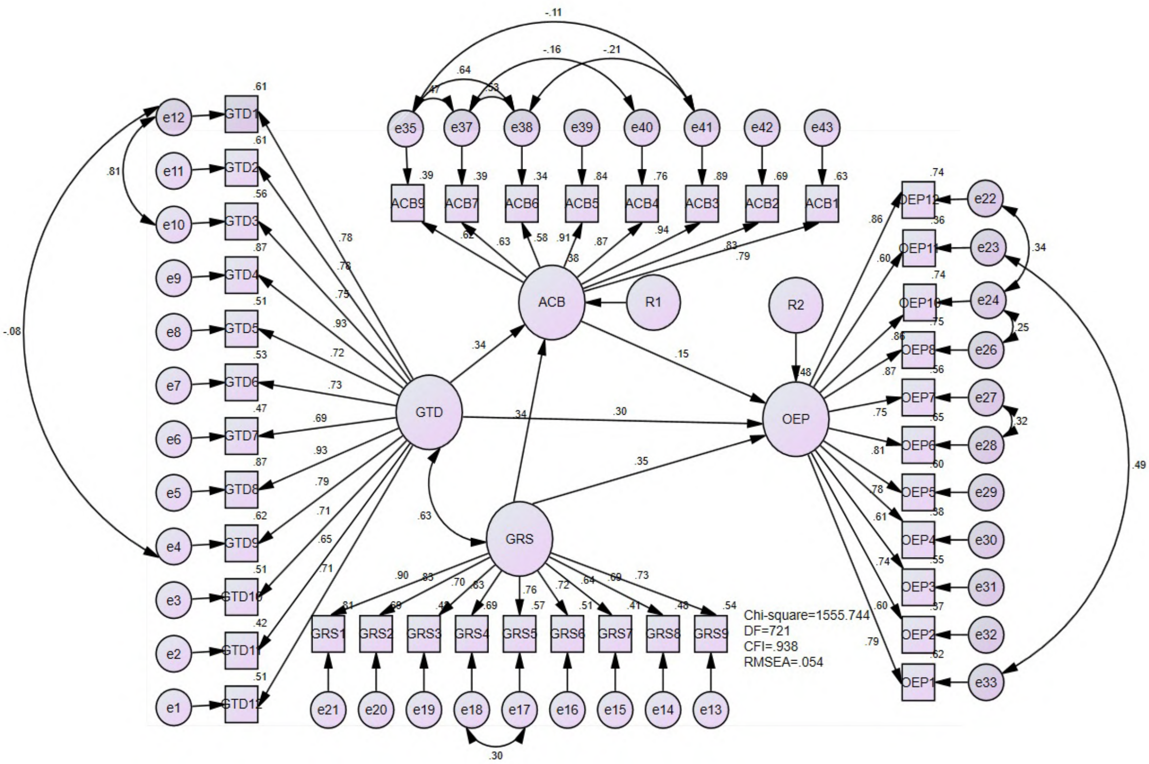
The discriminant validity index value for the model's constructs is displayed in Table 6 for each construct. According to Table 4, all of the components in this model have attained discriminant validity since the diagonal value is higher than the values in the rows and columns (Awang, 2011, 2012, 2014, 2015). This demonstrates that the model's multicollinearity is not a concern. The Confirmatory Factor Analysis model was judged acceptable and could move on with developing the Structural Equation Modelling if all the prerequisites for evaluating the Unidimensionality, Validity, and Reliability for the Measurement Model are satisfied.

Table 4. Discriminant Validity Index Summary for the Construct

	Green Recruitment and Selection	Green Training and Development	Organization Environmental Performance	Academic citizenship behavior
Green Recruitment and Selection	**0.758**			
Green Training and Development	0.635	**0.770**		
Organization Environmental Performance	0.623	0.607	**0.758**	
Academic citizenship behavior	0.551	0.554	0.512	**0.808**

Source: By Authors (Data Analysis Results)

Figure 2. The Structural Equation Modelling (SEM)



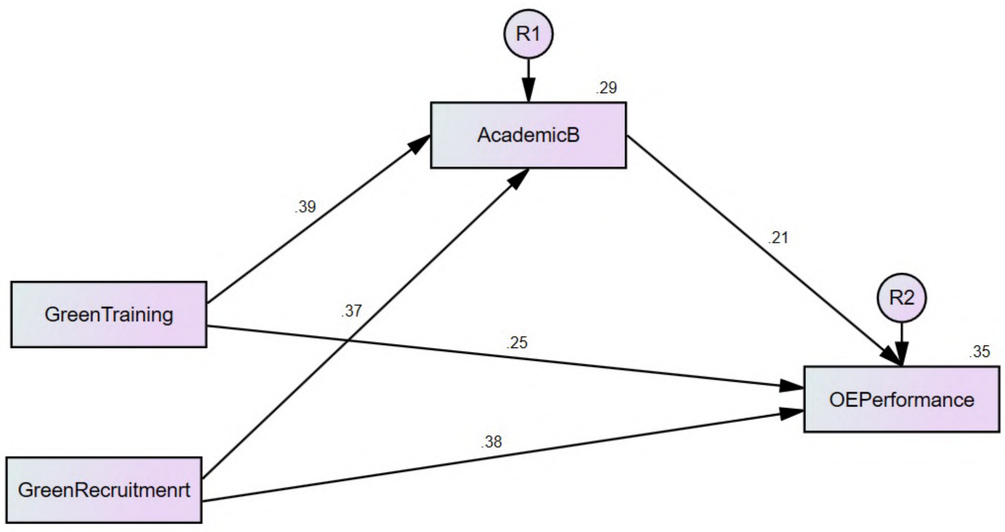
Source: (Amos Data Analysis Results)

10. HYPOTHESES TESTING

A few requirements must be met in order to analyze the mediating role in the relationship between the independent and dependent variables. These include the relationship that exists directly between the independent variable and the dependent variable, as well as the relationship that exists indirectly through the mediator variable (Awang, 2014; 2015). Only when the direct effect is statistically significant is the mediation effect pertinent. The mediator has an indirect mediating role in the relationship between the independent variable and the dependent variable if the direct effect of the independent variable on the dependent variable is diminished and the indirect effect (via the mediator) is significant.

The bootstrapping procedure was performed 2000 times to calculate confidence intervals of 90% to calculate the indirect effects. The lower and upper confidence intervals must be positive or negative do not include zero in order to judge the existence of statistical significance for the mediating effect (Preacher & Hayes, 2008). Figure 3 shows the path analysis results for Hypothesis testing using bootstrapping.

Figure 3. Path analysis results for Hypothesis



Source: (Amos Data Analysis Results)

According to Table 5, the empirical results supported the existence of a statistical significance of the direct effect between green training and development and academic citizenship behavior, as the results were (Estimate = 0.395, p = 0.000); also the direct effect between green recruitment and selection and academic citizenship behavior as the results were (Estimate = 0.371, p = 0.000); other effects between academic citizenship behavior and organization environmental performance as the results were (Estimate = 0.210, p = 0.000); table 5 shows also the positive significant effect between green training and development and organization environmental performance as the results were (Estimate = 0.247, p = 0.000); and significant effect between green recruitment and selection and organization environmental performance as the results were (Estimate = 0.378, p = 0.000).

Table 5. Results of hypotheses testing (Direct Effect)

H				Estimate	S.E.	C.R.	P	Label
H1	ACB	<---	GT&D	.395	.042	9.429	***	par_1
H2	ACB	<---	GR&S	.371	.043	8.870	***	par_4
H3	OEP	<---	ACB	.210	.040	4.394	***	par_2
H4	OEP	<---	GT&D	.247	.037	5.569	***	par_3
H5	OEP	<---	GR&S	.378	.038	8.606	***	par_5

Source: By Authors (Data Analysis Results)

According to Table 6, the empirical results supported the existence of a statistical significance of the indirect effect of academic citizenship behavior in the relationship between green training and development and organization environmental performance, as the results were (Estimate = .069, p = 0.001), and the confidence intervals did not include zero (lower = 0.037, upper = 0.114) This confirms the existence of statistical significance for this effect.

And the empirical results supported the existence of a statistical significance of the indirect effect of academic citizenship behavior in the relationship between green recruitment and selection and organization environmental performance, as the results were (Estimate = .067, p = 0.001), and the confidence intervals did not include zero (lower = 0.035, upper = 0.112) This confirms the existence of statistical significance for this effect.

Table 6. Results of hypotheses testing (Indirect Effects)

H	Indirect			Estimate	Upper	Lower	P
H6	OEP	<---	GT&D	.069	.114	.037	.001
H7	OEP	<---	GR&S	.067	.112	.035	.001

Source: By Authors (Data Analysis Results)

Table 7.The Results of Hypothesis Analysis

	Hypothesis	Estimate	Result	Analysis
H1	Green training and development at Government Universities are positive effect on an organization environmental performance.	.247	Accepted	SEM
H2	Green recruitment and selection at Government Universities are a positively effect on an organization environmental performance.	.378	Accepted	SEM
H3	Green training and development at Government Universities are positively effect on academic citizenship behavior.	.395	Accepted	SEM
H4	Green recruitment and selection at Government Universities are positively effect on an academic citizenship behavior.	.371	Accepted	SEM
H5	Academic citizenship behavior at Government Universities are positively effect on organization environmental performance.	.210	Accepted	SEM
H6	Academic citizenship behavior mediates the effect positively between green training and development on organization environmental performance.	.069	Accepted	SEM
H7	Academic citizenship behavior mediates the effect positively between green recruitment and selection on organization environmental performance.	.067	Accepted	SEM

Source: By Authors (Data Analysis Results)

The table 7 indicates that H1 “Green training and development at Government Universities are positive effect on an organization environmental performance.” suggests that implementing training and development programs with a focus on environmental sustainability within government universities can lead to favorable outcomes in terms of the institution’s environmental impact. the outcomes of the green training and development programs are beneficial and contribute to the improvement of the university’s environmental performance. Positive effects may manifest in various ways, such as reduced environmental impact, enhanced sustainability practices, and a heightened sense of environmental responsibility among the university community. Also, H2 “Green recruitment and selection at Government Universities are a positively effect on an organization environmental performance.” suggests that adopting environmentally conscious practices in the recruitment and selection processes of government universities can lead to favorable outcomes in terms of the institution’s overall impact on the environment, this could involve assessing candidates based on their awareness of environmental issues, previous experience with sustainability initiatives, or their alignment with the institution’s green values. H3 “Green training and development at Government Universities are positively effect on academic citizenship behavior.” implies that implementing training and development programs with a focus on environmental sustainability within government universities contributes positively to the behavior of academic citizens, this This could include training on ecological awareness, sustainable research methods, and the integration of environmental considerations into academic activities. H4 “Green recruitment and selection at Government Universities are positively effect on an academic citizenship behavior.” suggests that incorporating environmentally conscious practices in the recruitment and selection processes of government universities contributes positively to the academic citizenship behavior of individuals within the academic community. H5 “Academic citizenship behavior at Government Universities are positively effect on organization environmental performance.” suggests that the ethical and responsible conduct of individuals within the academic community, referred to as academic citizenship behavior, contributes positively to the environmental performance of government universities. H6 “Academic citizenship behavior mediates the effect positively between green training and development on organization environmental performance.” suggests that the positive influence of green training and development on organizational environmental performance is channeled through the mediation of academic citizenship behavior. This emphasizes the importance of cultivating a culture of responsible and environmentally conscious behavior within the academic community as a means to enhance overall environmental performance in the organization. H7 “Academic citizenship behavior mediates the effect positively between green recruitment and selection on organization environmental performance.” suggests that the positive influence of green recruitment and selection on organizational environmental performance is channeled through the mediation of academic citizenship behavior. This emphasizes the importance of cultivating a culture of responsible and environmentally conscious behavior within the academic community as a means to enhance overall environmental performance in the organization.

11. CONCLUSIONS, IMPLICATIONS, LIMITATIONS AND FURTHER RESEARCH

In Jordan for the past ten years, the university sector has been regarded as one of the most significant industries. The current study’s findings have confirmed those of earlier investigations and shown a link between green human resource management, academic civic engagement, and organizational environmental performance in Jordan’s public institutions. These findings support the notion that promoting and enhancing an organization’s environmental performance at work can be accomplished by holding a very positive level of environmental training, development, and recruitment. The efficient application of GHRM techniques also fosters the growth of civic engagement among students, enhancing the environmental performance of the company.

The study concludes that the implementation of green training and development, along with green recruitment and selection practices, has a positive impact on the environmental performance of Jordanian Government Universities. The integration of sustainability principles into academic citizenship behavior fosters a culture of environmental responsibility. Academic citizenship behavior serves as a catalyst for positive environmental practices. The study finds that when individuals within the academic community exhibit ethical and environmentally conscious behavior, it contributes significantly to the overall environmental performance of the institutions. The findings suggest that the initiatives studied contribute to a cultural shift within Jordanian Government Universities, aligning the academic community with global sustainability goals. The incorporation of green practices is not just a set of isolated activities but reflects a broader commitment to sustainable values.

Implications include the integration of environmental sustainability into academic curricula. This ensures that the principles learned through green training and development are embedded in the educational experiences of students, creating a lasting impact on future generations. The study suggests the importance of continuous professional development programs that reinforce green practices for faculty and staff. This ongoing training ensures that the academic community remains informed and engaged in sustainable practices. Collaboration with stakeholders, including government bodies, non-governmental organizations, and local communities, is crucial. Joint efforts can amplify the impact of green initiatives, leading to a more comprehensive and holistic approach to environmental sustainability.

The study acknowledges the limitations regarding the generalizability of findings. The context of Jordanian Government Universities may differ from other educational institutions, limiting the direct applicability of the study's conclusions to diverse settings. The study may have a limited timeframe, and the long-term impact of green initiatives may not be fully captured. It is essential to recognize that the effects of cultural and behavioral changes may take years to manifest fully.

It is advised that other GHRM practices, such as those that focus on employee development, be studied for future research to ensure that the results are better, more useful, and more thorough. Future research might employ a different kind of sampling approach, like a straightforward random sampling strategy, in place of the practical sampling method utilized in this study. Furthermore, because the present study was carried out in Jordan, it is not possible to extrapolate its findings to other geographic areas. Future research can carry out the same investigation in other developing nations, such the Middle East.

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ECONOMICS
Innovative and Economics Research Journal
Volume 12, No. 1, 2024
www.economicsrs.com

MODELLING THE DEMAND FOR INDONESIA'S FOREIGN RESERVES

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Received 08.01.2024. | Sent to review 18.01.2024. | Accepted 04.04.2024.

Original article

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JEL Classification: E58, F31, G15, O11, C32

Doi: 10.2478/eoik-2024-0005

UDK: 339.74:336.745(594)

ABSTRACT

The foreign reserves sufficiency is important to maintain macroeconomic stability. The main objective of this paper is to model the behaviour of the central bank in accumulating the foreign reserves in the case of Indonesia. Unlike the previous empirical studies, this paper disaggregates the components of foreign reserves into foreign currency, securities, gold, and special drawing rights. This paper relies on the Almost Ideal Demand System combined with the Error Correction Model. The estimation result for monthly data over the period 2010(1)-2020(12) reveals that the own-price coefficients are negative and statistically significant which is consistent with the standard theory of demand. While the foreign currency-securities pairwise is substitutive, the foreign currency-gold and the foreign currency-special drawing rights pairwise are complementary or even independent. However, the wealth effect is inelastic except for securities reserves. These results imply that the central bank of Indonesia can re-balance its reserves. The securities holding which have the highest proportion of foreign reserve scan be switched to foreign currency, gold, and/or special drawing rights. The rebalancing measures would remain having an optimal level of foreign reserves holding in terms of its opportunity cost. Therefore, the monetary authority can conduct a further macroeconomic stabilisation without substantially losing the returns.

Keywords: *Foreign Reserves, Cost of Holding Foreign Reserves, Demand System, Error Correction Model*

1. INTRODUCTION

The sufficiency of foreign reserves especially in developing countries is important to maintain macroeconomic stability. It is not surprising therefore that over the last two decades, there has been an increase in the stock of foreign exchange reserves in most developing countries. . International reserve holdings, which averaged about 5 percent of GDP in the 1980s, has been increased to 25 percent of GDP by 2010 (Ghosh et al., 2016). Under the high reserves, they can relatively survive from any external turbulence. The experience of many emerging markets during the global financial crisis in 2008-2009 and Taper Tantrum episodes in 2013, for example, suggests that having relatively large reserves could result in smaller exchange rate depreciations (Arslan and Cantú, 2019).

The above phenomenon is interesting. From the point of view of researchers, the accumulation of reserves is a critical test for the validity of precautionary motives when confronted with mercantile motives. According to the precautionary motives, on the one hand, countries hold reserves as a shock absorber in order to meet unexpected and temporary fluctuations in international payments (Aizenman and Lee, 2007). On the other hand, the mercantile motives argue that international reserves are used to facilitate export growth by averting exchange rate appreciation in order to support export competitiveness and foreign direct investment inflows (Shijaku, 2012).

Froma policymaker's point of view, the high reserves – irrespective of the motive – can dampen the negative impact on the domestic financial market. The growth and size of reserves also serve as signals dealing with the credibility of monetary policy (Andriyani *et al*., 2020). They also provide clarity and certainty of future monetary policy as a useful forward guidance to financial markets (Lebedeva and Shkuropadska, 2023). Eventually, holding a relatively high level of international reserves reduces the vulnerability to promote growth (Cheung and Qian, 2007). The holding of large foreign reserves involves a high degree of risk (Khan and Wang, 2023). The appreciation of domestic currency increases the risk of loss of value of the international reserves with a cost in aggregate income or welfare foregone (Chan, 2007). The continuous reserves accumulation could lead to disrupt the financial markets (Mohanty and Turner, 2006). The holding of foreign reserves has also an opportunity cost when these financial resources are used in a number of productive projects (Green and Torgeson, 2007).

Considering the benefits and costs, the increase in reserves may raise concerns on how developing countries manage their reserves, by continually preserving undervalued exchange rates, and even jeopardising the stability of the international monetary system (Portes, 2010; Dadush and Stancil, 2011; andGhosh *et al*., 2017). Moreover, in the empirical strand, recent studies have failed to explain the role of opportunity cost on the reserves holding. Some countries are less sensitive to its opportunity cost or even insignificant on the optimal foreign reserves (Molapo and Thamae, 2015; Prabheesh *et al*., 2007; Sooriyan, 2017; Puška *et al*., 2018; Oyeniran and Alamu, 2020; and Islam, 2021). Others found that foreign reserves holding are responsive to its opportunity cost so that the actual foreign reserves were above the optimal level (Sinem and Nebiye, 2014; Sanusi *et al*., 2019; Tran and Le, 2020; and Rashid and Basit, 2021).

Accordingly, there has been no consensus on the effects of opportunity cost (or return) on the foreign reserves holding (Abid and Saqlain, 2023). As a consequence, there has been no uniform level of foreign reserves that is universally regarded as either adequate or optimal. Since the circumstances vary across the economy, the amounts of foreign reserves held by the authorities in various countries are not the same, depending on the set of policy-predetermined and other objective factors. In general, developed countries with their floating and highly liquid currencies and stable financial markets tend to derive insignificant value from holding precautionary reserves policy. In contrast, emerging economies whose less liquid currencies and less stable financial markets tend to hold high levels of foreign reserves to reduce both the impacts of current account shocks and capital account crises (Bhakri and Verma, 2021).

Indonesia is not an exception. The foreign exchange reserves held by the central bank of Indonesia steadily increases since 1990 (see Figure 1). As an open economy with a floating exchange rate system, the accumulation of reserves is quite important to face domestic currency volatilityas happened in the 1997 Asian monetary crisis and the 2008 global financial crisis. The central bank of Indonesia's international reserves skyrocketed to US$138 billion as of January 2021, creating a new record high. The portfolio was equivalent to around 12. 5 percent of GDP andcould cover 10 months of imports – much greater than the conventional wisdom of three-month minimum sufficiency standard. While the foreign exchange reserves descended in the first quarter of 2020 in accordance with pandemic Covid-19 outbreak, they remained to steadily grow on the annual basis and performed a long term increasing trend (Jeffrey *et al*., 2021).

The increase in foreign reserves for Indonesiais needed to implement various macroeconomic measures (Mastilo *et al*., 2024). Strengthening monetary policy, for example, is likely to require an increase in the international reserves. In light of the fact that Indonesia is an open economy, small-country in the international context, the scope for actively manipulating international trade as well as affecting the global financial market to increase foreign exchange inflows remains limited. Moreover, as many developing Asian countries, Indonesia faces large external risks in the medium term so it would be suboptimal to cut back international reserves to make more room for speculative attacks. This brings back the role of opportunity costs in the central bank's behaviour in foreign reserves holding.

This paper contributes the literature on international monetary economics in the context of developing countries with focus on Indonesia. Unlike the previous studies which focus merely on the total foreign reserves and exchange rate, interest rate, and gold price as the main opportunity costs, this paper disaggregates the foreign reservesinto foreign currencies, securities, gold, and special drawing rights. Since they have their own opportunity cost, we model them simultaneously on the demand theory basis. Hence, the behaviour of the monetary authority in holding each reserve component in relation to monetary policy can be analysed further. Hopefully, the lessons from Indonesia will be fruitful to develop a better stabilisation monetary policy design for other developing countries.

Figure 1. Foreign Reserves and Month Import

Source: IMF

2. LITERATURE REVIEW

In the international monetary economics literature, the discussion of foreign exchange reservesis often related to the exchange rate system. On the one hand, under a fixed or pegged exchange rate system, countries or monetary authorities need to have adequate international reserves. In its most extreme form, monetary authorities implement a foreign exchange control system. Accordingly, the foreign exchange supply curve is assumed to be horizontal.It means that the monetary authority will meet whatever foreign currency is demanded. The inability to meet the demand for foreign exchange resulted in the failure of the fixed or pegged exchange rate system.

On the other hand, the monetary approach of balance of payment believes that the foreign currency and domestic currency are substitutable for each other. Therefore, a change in foreign reserve holdings is associated with the disequilibrium in the domestic money market (Ford and Huang, 1994). International reserves will enlarge when there is an excess demand for money, by assuming that the domestic credit is constant; and conversely international reserves will shrink if there is an oversupply of money (Lee and Yoon, 2020). Thus, according to the monetary approach, the international reserves are residual holding by a country (Edwards, 1985).

Reconciling the two approaches above, the movements of reserves respond to deviations between the desired reserves (to preserve the fixed exchange rate) and the actual reserves (as a disequilibrium in the domestic money market) held by a country (Clark, 1970; Edwards, 1985). In this regard, most empirical studies were motivated by a monetary approach to the balance of payments rather than the fixed exchange rate approach (Elbadawi, 1990; Badinger, 2004). The lack of countries that adhere to a fixed exchange rate system is suspected to be the primary cause, especially since the collapse of the Bretton Woods fixed exchange rate system in early 1970s.

Under a pure flexible exchange rate system, on the other hand, countries theoretically need not have much reserve (Lee and Yoon, 2020). The exchange rate is solely determined in the market mechanism through full interaction between demand and supply forces. Monetary authorities do not necessarily intervene in the market. As a result, the price of foreign currency in terms of domestic currency will increase sharply when there is an excess demand for foreign currency. In contrast, the price of foreign exchange will decrease deeply if there is an excess supply of foreign currency. In short, the exchange rate under the pure flexible exchange rate systemis quite fluctuating.

To reduce the exchange rate fluctuations, many countries adopt the managed float exchange rate system. Under the managed float exchange rate system, monetary authorities intervene in the foreign exchange market. The monetary authorities will buy the foreign exchange when the price is considered ‘too low’ and sell the foreign exchange when the price is claimed ‘too high’ from the desirable rate. Sellingthe foreign exchange needs international reserves. Accordingly, international reserves in themanaged float exchange rate system can be up and down. The exchange rate is somewhat more stable compared to the pure flexible exchange rate system (Melvin and Norrbin, 2017).

Even though adopting a managed float exchange rate system, countries may still hold adequate foreign reserves. The underlying motives are generally classified in two groups, namely the precautionary and mercantile motives (Mendoza, 2004). The former refers to the fact that countries with a high degree of economic openness are likely to come across random shocks to their external balance, which creates temporary deviations between international payments and receipts or produces balance of payments discrepancy (Zatonatskiy and Lavrentiev, 2023). Under such conditions, the international reserves can be employed as a shock absorber, reflecting the economy’s ability to cover the payments deficit without suffering unfavourable adjustments (Aizenman and Lee, 2007; and Chan, 2007).

There are some further arguments to explain why countries hold sufficient international reserves. Steiner (2013) attributes accumulation of foreign reserves mainly to the ‘fear of capital mobility’. Steiner (2013) argues that accumulation of official reserves is used to compensate for the capital market’s liberalisation. This is contrary to the findings by Calvo and Reinhart (2002) which argue that ‘fear of floating’ rather than ‘fear of capital flight’ is the main determinant of reserve holdings especially in emerging Asian economies. Meanwhile, Yeyati *et al*. (2013) brought the issue of asymmetry into the discussion of the ‘fear of floating’ as the sole determinant of reserves accumulation.

Regarding the mercantile motive, Shijaku (2012) argues that international reserves are used to facilitate export growth by hindering exchange rate appreciation in order to support export competitiveness and foreign direct investment inflows. Therefore, most of the regulations related to the demand for foreign exchange reserves of a country refer to the mercantile motives. Jovanovic and Frenkel (1981) state that the mercantile motive stake into account several variables, such as imports, exports, foreign debt, and the level of trade shocks that may occur, as well as consideration of monetary policy. However, mercantile motive has playeda less prominent role relative to precautionary motives in explaining the hoarding of international reserves by developing countries (Aizenman and Lee, 2007). Several studies, including Winjuholds and Kapteyn(2001), Cheung and Qian (2009), Bastourre *et al.*(2010), Obstfeld *et al.*(2010), and others also support the importance of precautionary motives.

A high level of international reserves is also costly, however (Protsenko, 2023). The reserve accumulation could result in high economic and social costs, including a high opportunity cost originating from low returns on reserve assets, losses in consequence of reserve currency depreciation, and forgone earnings from investment and public expenditures that could be borned by these reserves (Elhiraika and Ndikumana, 2007). Rodrik (2006) found that differences between the yield on reserve assets and the cost of foreign borrowing in developing countries induced an income loss of approximately one percent of GDP due to the increase in foreign exchange reserves.

The excessive reserves accumulation also contributes to higher price levels and overheating bank loan and asset markets (Mohanty and Turner, 2006). Moreover, efforts to stabilise its effect on the domestic money supply might harm domestic banking systems, while its efficacy in avoiding real exchange rate appreciation in the long run is not robust yet (Dadush and Stancil, 2011). The high level of foreign reserves could create the loss of resources which could be better off if the reserves have been employed in alternative ways such as investment in the infrastructural facilities (Green and Torgeson, 2007). In developing countries, for example, the opportunity cost could be high due to the demand for funds to cover developmental projects is always greater than the available supply (Mishra and Sharma, 2011).

Regardless of the precautionary-mercantile motives and the exchange rate regimes, the demand for foreign reserves always exists (Oskoee and Brown, 2002). The international reserves are considered asnecessary financial resources of an economy (Molapo and Thamae, 2015). Therefore, the international reserves tend to be stockpiled to a high level or even greater than the optimal one (Fazlollahtabar, 2022). The optimal level of foreign reserves is defined as that which maximises the difference between benefit and cost derived from holding reserves. More specifically, the optimal amount of reserves depends on the balance between the total adjustment costs emerging from reserves depletion and the opportunity cost of holding reserves (Heller, 1966).

Pioneered by Heller (1966), empirical studies on demand for foreign reserves have been conducted extensively (Clark, 1970; Jovanovic and Frenkel, 1981; Edwards, 1985; Ford and Huang, 1994; Mendoza, 2004; Rodrik; 2006) for multicountry. Nevertheless, recent empirical investigations in developing countries have dealt with the cost of holding reserves. Prabheesh*et al.*(2007) and Sooriyan (2017) show that foreign reserve accumulation in India is less responsive to its opportunity cost. The same result is found in the case of Lesotho (Molapo and Thamae, 2015), Pakistan (Azeem and Khurshid, 2019), and Bangladesh (Islam, 2021). Oyeniran and Alamu (2020) show that the opportunity cost of holding reserves has an insignificant impact on Nigeria's optimal foreign reserves. Conversely, Sinem and Nebiye (2014) indicates that the opportunity cost strongly affected the reserve demand in the Turkish case.

The diverging results above measure the opportunity cost mostly using interest rate differential

(Shevchenko, 2023). Other researchers expand the scope of opportunity cost. In a panel study for Southern African countries, Sanusi*et al.*(2019) conclude that exchange rate and inflation rate are significant determinants of foreign reserve holdings. Rashid and Basit (2021) found that gold price volatility positively contributes to exchange rate volatility in Bangladesh, Indonesia, and Malaysia, resulting in their actual foreign reserves were above the optimal level. In contrast, Tran and Le (2020) show lending rate of home currency (as a proxy of opportunity cost) induced the optimum reserves in Vietnam close to the actual ones.

Purely in the case of Indonesia, the related studies are still limited. Diwantari (2010) obtained that the long term determinant of the international reserves holding has not only a precautionary motive, but also a mercantile motive. Her research unfortunately shows that interest rate differential insignificantly influences the central bank on deciding its international reserves level in the long term. Andriyani *et al.* (2020) found that the exchange rates negatively and significantly affect the foreign exchange reserves, meanwhile the inflation rate has an insignificant negative effecton the foreign exchange reserves.

In general, the above empirical studies rely on the foreign exchange reserves in the whole term, implying the opportunity cost of holding reserves is measured by a single variable. None study breaks down the foreign exchange reserves into their individual components along with their respective opportunity cost. This research examines foreign exchange reserves which are divided into four main components, i. e. foreign currency, securities, gold, and special drawing rights whose own-opportunity cost. Those are analysed simultaneously in the demand system framework. Taking the case of Indonesia, this approach allows us to identify substitutability, complementarity and/or independence possibility of each pairwise of the foreign exchange reservescomponent to arrange the optimal reserves composition.

3. ANALYTICAL FRAMEWORK

Modelling an economic agent's behaviour to consume goods/services begins with the estimation of demand functions extracted from neoclassical consumer theory. Four flexible demand systems have received considerable attention in the literature since their relative empirical worthiness. They are the Linear Expenditure System (LES) developed by Stone (1954), the transcendental utility logarithmic function (translog) proposed by Christensen*et al.*(1975), the Almost Ideal Demand System (AIDS) developed by Deaton and Muellbauer (1980), and the Quadratic Almost Ideal Demand System (QUAIDS) of Banks*et al.* (1997).

In our empirical analysis, we employ the QUAIDS model which is based upon the AIDS model. The QUAIDS allows us to have a more flexible Engel curve shape. The nonlinear terms are restricted to be a quadratic in log income to offer a significantly better fit of budget shares to changing income levels while remaining a parsimonious model specification (Yoon and Heo, 2017). This model is designed to estimate a complete demand system which is in line with both microeconomic theory and available expenditure and price data. Adding up the quadratic log income term in the AIDS model allows goods to be luxuries at some income levels but necessities at others (Oliver, 2014).

The QUAIDS has rank three as the usual linear AIDS and translog models. It can also better estimate non-linear Engel curves in the empirical works. Since a QUAIDS model generates a considerably larger regular region than the locally flexible forms, it can be categorised as effectively globally regular. The corresponding utility and indirect functions, and cost functions meet their theoretical requirements for all non-negative demand, price, and all utility levels as appropriate. The QUAIDS model refers to the following indirect utility function (U):

$$lnU(P,Y) = \left[\left\{\frac{lnY - ln\,a(P)}{b(P)}\right\}^{-1} + \lambda(P)\right]^{-1} \tag{1}$$

where the term in the brace is the indirect utility function of a Price-Independent Generalised Logarithmic (PIGLOG) demand system, Y indicates total wealth of economic agents, and P represents a vector of prices. $a(P)$ is a differentiable and homogeneous function of degree one in prices. The form of λ(P) and $b(P)$ are homogeneous functions of degree zero in prices.

These functions are defined as:

$$ln\,a(P) = a_0 + \sum_{i=1}^{k} a_i\, lnp_i + \frac{1}{2}\sum_{i=1}^{k}\sum_{j=1}^{k}\gamma_{ij}\, ln\,p_i\, lnp_j \tag{2a}$$

$$b(P) = \prod_{i=1}^{k} p_i^{\,b_i} \tag{2b}$$

$$\lambda(P) = \sum_{i=1}^{k}\lambda_i \ln p_i, \text{ where } \sum_{i=1}^{k}\lambda_i = 0 \tag{2c}$$

Implementing the Roy's identity into the indirect utility function as Equation (1), we get the budget share equation for commodity i:

$$s_i = \frac{\vartheta \ln a(P)}{\vartheta \ln p_i} + \frac{\vartheta \ln b(P)}{\vartheta \ln p_i}(\ln Y) + \frac{\vartheta\lambda}{\vartheta \ln p_i}\frac{1}{b(P)}(\ln Y)^2 \tag{3}$$

where s_i is defined as $s_i = p_i q_i / Y$ representing the budget share for commodity i. In line with the relevant economic theory, the parameters should impose the restrictive conditions that (i) aggregation: $\sum_{i=1}^{k} a_i = 1$, $\sum_{i=1}^{k} b_i = 0$, $\sum_{j=1}^{k}\gamma_{ij} = 0$, (ii) homogeneity: $\sum_{j=1}^{k}\gamma_{ij} = 0$, and (iii) symmetry: $\gamma_{ij} = \gamma_{ji}$.

Substituting Equation (2) to Equation (3), we obtain the QUAIDS expenditure share equation:

$$s_i = a_i + \sum_{j=1}^{k}\gamma_{ij}\ln p_j + b_i \ln\left\{\frac{Y}{a(p)}\right\} + \frac{\lambda_i}{b(p)}\left[\ln\left\{\frac{Y}{a(p)}\right\}\right]^2 \tag{4}$$

When the quadratic term is zero, Equation (4) will become the AIDS model which is the most widely used for modelling consumption patterns for grouped commodities.

The coefficient of b_i represents 100 times the effect on the share of commodity i (s_i), of a 1 percent increase in wealth, with all commodity prices remaining constant. The coefficient of γ_{ij} measures the effect on s_i of a one percentage point increase in the commodity price p_i, all other things being equal.

To apply the QUAIDS model in the international reserves, we assume that the central bank has four main foreign reserves, i. e. foreign currency (C), securities/bonds (B), gold (G), and special drawing rights (S). The central bank's utility is an increasing function of the four foreign reserves:

$$U = f(C, B, G, S) \tag{5}$$

Each foreign reserve has a different return or price. The return can be symmetrically considered as the opportunity cost. Therefore, we can rewrite:

$$Z = C + B + G + S \tag{6}$$

The nominal reserve value is the multiplication of price and quantity. This notion is applied on the whole individual reserves:

$$Y = PZ = \sum_{i=1}^{k} p_i z_i \tag{7}$$

Under those conditions, the central bank is assumed to maximise utility as Equation (5) subject to the budget line as Equation (7), yielding the ordinary theory of demand. By inserting Equations (5) and (7) into the QUAIDS, we have:

$$s_i \equiv \frac{p_i z_i}{Z} = a_i + \sum_{j=1}^{k} b_{ij} \ln p_j + c_i \ln\left\{\frac{Z}{P}\right\} + d_i \left[\ln\left\{\frac{Z}{P}\right\}\right]^2 \quad (8)$$

The linear-approximate QUAIDS should be run as a system of equations by imposing some restrictions on the parameter estimates. The own-price elasticity can be calculated from the structural parameter estimates as:

$$\epsilon_{ii} = -1 + \left(\frac{b_i}{s_i}\right) - c_i + \left[2\, d_i \ln \frac{Z}{P}\right] \quad (9)$$

The uncompensated (Marshallian) price elasticity of commodity *i* with respect to change in the price of reserve *j* is

$$\epsilon_{ij} = \left(\frac{b_{ij}}{s_i}\right) - \left(\frac{c_i}{s_i}\right) s_j + \left[\left(2\, d_i \ln \frac{Z}{P}\right)/s_j\right] \quad (10)$$

The income (wealth) elasticity for reserve *i* is

$$\epsilon_{iZ} = 1 + \left(\frac{c_i}{s_i}\right) + \left[\left(2\, d_i \ln \frac{Z}{P}\right)/s_i\right] \quad (11)$$

Equation (9) implies that if the coefficient of b_i is positive, then commodity *i* will have a wealth elasticity greater than unity. Meanwhile, if the coefficient of b_i is negative, then commodity *i* will have a wealth elasticity less than unity.

Equation (8) represents the long run demand function as expected by theory. In the short-run, we propose the error correction demand system for reserve *i* as suggested by Engle and Granger (1987):

$$\Delta s_i \equiv \Delta \frac{p_i z_i}{Z} = \sum_{j=1}^{k} b_{ij} \Delta \ln p_j + c_i \Delta \ln\left\{\frac{Z}{P}\right\} + d_i \Delta \left[\ln\left\{\frac{Z}{P}\right\}\right]^2 + \varphi_i EC_{it-1} \quad (12)$$

where Δ is the first difference operator and EC_{it-1} is the error correction component created from the long-run demand system, i. e. the static almost demand system as specified by Equation (8). The application of error correction model has been extensively employed not only in the analysis of international reserves (Badinger, 2004; Gosellin and Parent, 2004; Prabeesh *et al.*, 2007; Diwantari, 2010, and Oyeniran and Alamu, 2020) but also in the macroeconomic policy (Kuncoro, 2018; 2019) and services industry (Yoon and Heo, 2017).

It seems more straightforward to directly analyse those variables. However, estimation of a single demand function produces the problem that the quantity demanded projections may not fulfil the requirements of demand theory, primarily the budget constraint. The estimation method proposed by Zellner (1962) for Iterative Seemingly Unrelated Regressions Estimation (ITSURE) serves the more efficient estimates. In the first stage, the ordinary least squares is used to estimate the variance-covariance matrix among residuals. In the second stage, the estimated matrix is employed in the generalised least squares estimation.

Since the covariance matrix among residuals is singular (because the residuals satisfy the budget constraint), the typical procedure consists in removing one of the equations of the demand system. The coefficients from the removed equation can be computed from the parameters of the other equations through the restrictions on them. In general, the result of ITSURE will be similar to the maximum likelihood estimators (Greene, 2012). To acquire a symmetric and homogeneous equation system, estimation on the shares of foreign currency, securities, and goldwill be done directly, while the estimation on the share of special drawing rights will be done indirectly. The ITSURE procedure yields the parameters of the system of equations which are invariant to the reserve-share equation dropped.

As outlined in the conventional theory of demand, the relationship between two goods vis-á-vis can be regarded as substitutive, complementary, and independent (see for example: Varian, 1992). The substitutability and/or independence among the four foreign reserves implies that the re-balancing international reserves policy is feasible to pursue. Conversely, the complementarity among thefour foreign reserves presents that the re-balancing international reserves policy is not advisable. In such a case, the change in portfolio composition will reduce the central bank revenue or the central bank will bear a higher opportunity cost.

4. RESULTS AND DISCUSSION

Since this study is concerned with the degree of substitutability and/or complementarity, thus this study needs reliable and long span time series data on foreign exchange reserves covering foreign currency, securities. monetary golds, and special drawing rights. The bilateral exchange rate of US Dollar against Rupiah is used as the price of foreign currency (as used by Andriyani *et al.*(2020)) to measure its opportunity cost. The price of a securities is represented by the 5-year treasury rate (as used by Diwantari (2010)). The price of gold in the world market (in troy ounce) serves as opportunity cost of holding monetary gold (as used by Rashid and Basit (2021)). The value of *special drawing rights* in terms of the *US Dollar* is used as the price of special drawing rights. In general, the data are collected primarily from the central bank of Indonesia, Bloomberg, World Bank, and IMF. The sample periods chosen for this study extend from 2010(1) to 2020(12). The 2010(1) is chosen as the starting point observation related to the diminishing adverse impacts of the 2008 global financial crisis on the Indonesian economy. The total observation is 132 sample points.

Table 1 performs the descriptive statistics comprising mean, median, and extreme (maximum and minimum) values. The share of securities reserves is the highest (84 percent) followed by foreign exchangereserves (11 percent). The high dollar-denominated securitie sand foreign exchange reserves holding is the common figure in developing countries (Gosselin and Parent, 2005). While, the distance between maximum and minimum values for the four foreign reserves are relatively small, all of the median foreign reserve share values are also close enough to the respective mean. The closeness of the median to the mean value preliminary indicates that all of the variables of interest are normally distributed.

However, the Jarque-Bera test rejects the normality distribution. The null hypothesis that most of the series data has the bell-shaped distribution can be rejected in 5 percent significance level. The asymmetric distribution of each foreign reserve share is supported by a non-zero value of skewness. The upper tail of the share of securities distribution, for example, is thicker than the lower tail. Also, the kurtosis coefficients are less than 3. It implies that the tail of the distribution is thinner (moderate) than the normal distribution. This raises a plausible question of whether (in relation to the highest share) the change in securities reserve holding will change the overall central bank's reserves.

The higher securities reserves compared to foreign exchange reserves suggests that the central bank pays more attention to maintaining international reserve holding optimality in terms of benefit and cost. Table 1 also reports the price of each foreign reserve accompanied by its standard deviation. The standard deviation shows how far the dataset spread from its mean. Statistically, a set data is said to be relatively volatile if its CV (coefficient of variation, ratio of standard deviation to its mean) is more than 50 percent. Based on the empirical regularity, the returns of securities and wealth have the highest CV implying that the associated variables are the most volatile. Accordingly, the central bank holds a high proportion of securities reserves to absorb its price volatility.

Table 1. Descriptive Statistics

	SC	SB	SG	SS	PC	PB	PG	PS	LOG(Z/P)
Mean	0. 1098	0. 8388	0. 0311	0. 0204	12, 077. 43	13. 86	1, 422. 23	0. 69	14. 0376
Median	0. 0970	0. 8593	0. 0307	0. 0230	13, 093. 00	15. 28	1, 357. 50	0. 70	13. 3372
Maximum	0. 2059	0. 9045	0. 0383	0. 0397	16, 310. 00	29. 78	2, 017. 00	0. 74	17. 8387
Minimum	0. 0219	0. 7370	0. 0251	0. 0117	8, 504. 00	0. 21	1, 083. 00	0. 62	12. 5388
Std. Dev.	0. 0455	0. 0487	0. 0040	0. 0074	2, 177. 50	8. 52	204. 32	0. 04	1. 4851
CV (%)	41. 39	5. 80	12. 72	36. 16	18. 03	61. 42	14. 37	5. 18	59. 44
Skewness	0. 5772	-0. 7514	0. 2556	0. 3617	-0. 3762	-0. 3465	0. 8474	-0. 2372	1. 2946
Kurtosis	2. 2907	2. 1641	1. 6779	2. 1313	1. 6111	2. 1937	3. 0754	1. 5771	3. 0319
Jarque-Bera	10. 0975	16. 2659	11. 0499	7. 0280	13. 7244	6. 2172	15. 8301	12. 3738	36. 8766
Probability	0. 0064	0. 0003	0. 0040	0. 0298	0. 0010	0. 0447	0. 0004	0. 0021	0. 0000
Observations	132	132	132	132	132	132	132	132	132

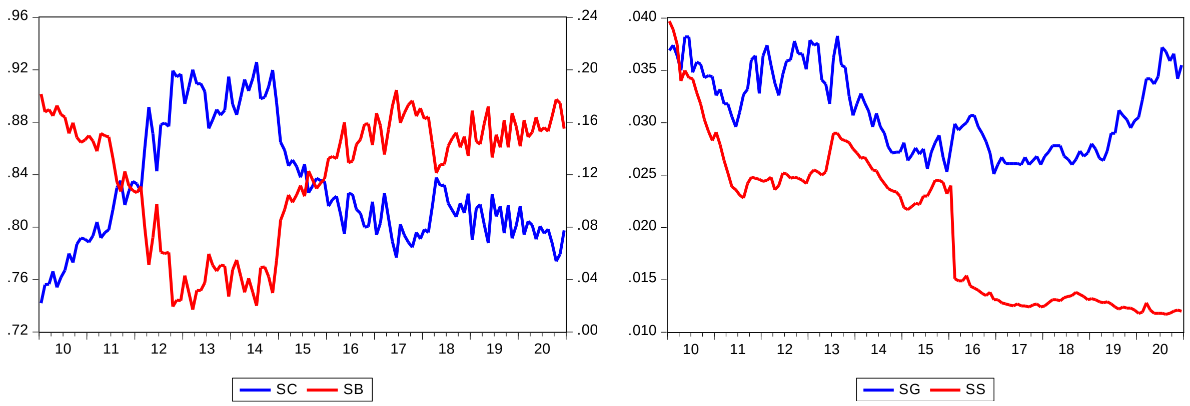
Note: SC = share of currency; SB = share of bond; SG = share of gold; SS = share of SDR
PC = price of currency; PB = price of bond; PG = price of gold; PS = price of SDR
Z = income = C + B + G + S

Source: Authors' work

Figure 2 delivers in more detail the movement of each foreign reserves holding for the whole period of observation. The curve of foreign currency shares has been declining consistently since January 2010. The turning point took place in the mid-2014. Since then, the share of foreign currency reserves has been increasing. In contrast, the share of securities reserves holding has been increasing and then has decreased sharply since the mid-2014 in accordance with the end of commodity boom. It means that the commodity boom episodes provided a lot of foreign currency inflows so that the central bank's foreign currency reserves also increased.

Comparing the shares of gold and special drawing rights reserves holding offers an interesting picture. The movement of gold reserves holding seems to be synchronous with the special drawing rights reserves holding. Accordingly, the two foreign reserves are likely complementary to each other. However, the share of gold and special drawing rights reserves holding is out of synchrony with the foreign currency and securities reserves holding. This raises a preliminary hypothesis that the foreign currency and securities reserves are substitutesto each other. We may also expect thatgold and special drawing rights are independent with the foreign currency and securities reserves holding. This will be examined later using more sophisticated devices.

Figure 2. Shares of Reserve



Source: Authors' work

Before estimating the short-run QUAIDS error correction model as Equation (12), we observe the stationarity of the variables. Table 2 performs the Augmented Dickey-Fuller (1979) unit roots test resultsfor the underlying series data both in levels and first differences. The null hypothesis of nonexistence of unit roots can be accepted for each of the variables in the level and thus we conclude that the series data are non-stationary. The nonrejection of the null hypothesis of unit roots may be the result of shifting deterministic trend.

However, the null hypothesis is rejected even at the 1 percent of significance level for all of series data in their first-differences. This indicates that after first-differencing, stationary is achieved, i. e. all the series data are *I(1)*. In such a case, all the variables in the first difference formsare stationary. It means that the behaviour of the variables moves around the mean value and time-invariant (Enders, 2004). The absence of unit roots in the series provides an early symptom of shocks having permanent or long lasting effect, thus making it very hard for conventional stabilisation policies to defend.

Table 2. Unit Roots Test

	Level			First-difference			Conclusion
	t-stat	SE	Prob.	t-stat	SE	Prob.	
SC	-1. 6670	0. 0291	0. 4456	-11. 3512	0. 1358	0. 0000	I(1)
SB	-1. 2002	0. 0265	0. 6732	-11. 0428	0. 1364	0. 0000	*I(1)*
SG	-2. 1737	0. 0308	0. 2169	-12. 0804	0. 0884	0. 0000	*I(1)*
SS	-2. 6581	0. 0117	0. 0842	-10. 7785	0. 0882	0. 0000	*I(1)*
PC	-1. 0962	0. 0136	0. 7161	-12. 5287	0. 0880	0. 0000	*I(1)*
PB	-1. 7030	0. 0285	0. 4274	-10. 9717	0. 0883	0. 0000	I(1)
PG	-1. 5666	0. 0297	0. 4968	-12. 4179	0. 0888	0. 0000	*I(1)*
PS	-1. 6771	0. 0204	0. 4405	-12. 8129	0. 0878	0. 0000	*I(1)*
Log(Z/P)	-1. 5681	0. 0314	0. 4960	-11. 8915	0. 0883	0. 0000	*I(1)*
(Log Z/P)^2	-1. 5193	0. 0313	0. 5209	-11. 8685	0. 0883	0. 0000	*I(1)*

Note: See Table 1

Source: Authors' work

The time series data stationary properties are compulsory to establish cointegration. Cointegration is a fundamental concept to investigate the long-run behaviour of the data. Cointegration is concerned with the analysis of long run relations between variables integrated of the same order and the speed of return to equilibrium after a deviation is measured by the Error Correction

Model (ECM). To prove our hypothesis, we again estimate the Augmented Dickey-Fuller unit roots test individually on the residual generated from Equation (8).

Table 3 shows the Engle–Granger (1987) cointegration test results. All the variables are *I(0)*, implying a cointegrating relationship (in levels) between all variables in Equation (8) exists. This means the existence of a long-run and stable relationship between the level of foreign exchange reserves and its determinants. Thus, any short-term difference in their respective values will disappear in the longer term. These preliminaries perform the presence of cointegration and thus approve the estimation of Equation (12).

Table 3. Cointegration Test

	t-stat	SE	Prob	Conclusion	
QUAIDS					
EC	-3. 9134	0. 0409	0. 0026	*I(0)*	Co-integrated
EB	-3. 9456	0. 0416	0. 0023	*I(0)*	Co-integrated
EG	-3. 9590	0. 0464	0. 0022	*I(0)*	Co-integrated
ES	-3. 3673	0. 0456	0. 0139	*I(0)*	Co-integrated
AIDS					
EC	-4. 8767	0. 0584	0. 0001	*I(0)*	Co-integrated
EB	-4. 8417	0. 0581	0. 0001	*I(0)*	Co-integrated
EG	-5. 5289	0. 0668	0. 0000	*I(0)*	Co-integrated
ES	-3. 6070	0. 0505	0. 0068	*I(0)*	Co-integrated

Source: Authors' work

The ITSURE estimation results of the Zellner's method (1962) for four equations are reported respectively in Table 4. The coefficient estimated structural equation model of the short run QUAIDS is statistically significant for most foreign reserve specifications verified by t-statistics value is greater than the related t-table at 95 percent or even 99 percent confidence levels. The parameter of error correction term is negative implying that our model is well-specified. The corresponding coefficient can capture the adjustment mechanism of all variables to the long run equilibrium.

However, the coefficient of quadratic termsin all equations is insignificant. The insignificance of the squared-log wealth does not permit foreign reserves to be luxuries at some wealth levels but necessities at others. Hence, we re-run the AIDS model (Deaton and Muellbauer, 1980), by removing the squared-log wealth. The results show that most coefficients of estimates are statistically much better. The coefficient of error correction term is also found to be negative implying the lagged residuals (generated from the linear regression) represent the deviation from the long-run relationship in the previous period. The inclusion of an error correction term ensures an appropriate test of the existence of a causal relationship between international reserves and their respective prices.

Those above results are also supported by the previous analysis from descriptive statistics, that all types of the foreign reserves are relatively unstable over the whole period of observation. However, our interest and further analysis are not devoted to the estimation results of the structural model (Table 4). The parameters whose economic meaning are the derived coefficients that demonstrate the price and wealth elasticity indices for the corresponding foreign reserve, instead (Table 5).

Table 4. Estimation Results of EC-(Quadratic) Almost Ideal Demand System

Dependent Variable	Independent Variable	QUAIDS			AIDS		
		Coeff.	SE	Prob.	Coeff.	SE	Prob.
Δ SC	Δ PC	0. 0577	0. 0288	0. 0461	0. 0683	0. 0287	0. 0179
	Δ PB	-0. 0562	0. 0271	0. 0386	-0. 0681	0. 0269	0. 0117
	Δ PG	-0. 0005	0. 0029	0. 8511	-0. 0007	0. 0028	0. 8063
	Δ PS	-0. 0010[a)]	0. 0056	0. 4902[e)]	0. 0005[a)]	0. 0048	0. 4822[e)]
	Δ Log Z/P	-0. 0206	0. 0687	0. 7641	-0. 0694	0. 0273	0. 0116
	Δ (Log Z/P)^2	-0. 0012	0. 0024	0. 6058	-		-
	EC(-1)	-0. 1942	0. 0366	0. 0000	-0. 1566	0. 0316	0. 0000
Δ SB	Δ PC	-0. 0562	0. 0271	0. 0386	-0. 0681	0. 0269	0. 0117
	Δ PB	0. 1012	0. 0265	0. 0002	0. 1110	0. 0265	0. 0000
	Δ PG	-0. 0269	0. 0028	0. 0000	-0. 0262	0. 0028	0. 0000
	Δ PS	-0. 0181[a)]	0. 0050	0. 0005[e)]	-0. 0167[a)]	0. 0343	0. 0001[e)]
	Δ Log Z/P	0. 0817	0. 0660	0. 2165	0. 1131	0. 0269	0. 0000
	Δ (Log Z/P)^2	0. 0007	0. 0023	0. 7540	-		-
	EB(-1)	-0. 1825	0. 0381	0. 0000	-0. 1491	0. 0331	0. 0000
Δ SG	Δ PC	-0. 0005	0. 0029	0. 8511	-0. 0007	0. 0028	0. 8063
	Δ PB	-0. 0269	0. 0028	0. 0000	-0. 0262	0. 0028	0. 0000
	Δ PG	0. 0280	0. 0016	0. 0000	0. 0276	0. 0015	0. 0000
	Δ PS	-0. 0006[a)]	0. 0024	0. 0378[e)]	-0. 0007[a)]	0. 0023	0. 0251[e)]
	Δ Log Z/P	-0. 0349	0. 0058	0. 0000	-0. 0266	0. 0028	0. 0000
	Δ (Log Z/P)^2	0. 0003	0. 0002	0. 1387	-		-
	EG(-1)	-0. 2591	0. 0603	0. 0000	-0. 2002	0. 0490	0. 0001
Δ SS	Δ PC	-0. 0010[a)]	0. 0056	0. 4902[e)]	0. 0005[a)]	0. 0048	0. 4822[e)]
	Δ PB	-0. 0181[a)]	0. 0050	0. 0005[e)]	-0. 0167[a)]	0. 0343	0. 0001[e)]
	Δ PG	-0. 0006[a)]	0. 0024	0. 0378[e)]	-0. 0007[a)]	0. 0023	0. 0251[e)]
	Δ PS	0. 0197[b)]	0. 0105	0. 0193[f)]	0. 0170[b)]	0. 0087	0. 0105[f)]
	Δ Log Z/P	-0. 0261[c)]	0. 0090	0. 0114[f)]	-0. 0171[c)]	0. 0041	0. 0000[f)]
	Δ (Log Z/P)^2	0. 0003[d)]	0. 0003	0. 5391[f)]	-	-	-
	ES(-1)	-0. 1177[f)]	0. 0706	0. 0963[f)]	-0. 1198[f)]	0. 0532	0. 0248[f)]

Note: See Table 1

SE is standard error

a) estimate is calculated from the restriction: $\sum b_i = 0$

b) estimate is calculated from the restriction: $\sum b_{ij} = 0$

c) estimate is calculated from the restriction: $\sum c_i = 0$

d) estimate is calculated from the restriction: $\sum d_i = 0$

e) standard error is taken from the direct estimation of share of C, B, and S

f) standard error is taken from the direct estimation of share of B, G, and S

Source: Authors' work

The own-price elasticity is found to be negative for all foreign reserves. The minus sign of own-price elasticity meets the requirement of conventional theory of demand behaviour. This means that a rise of 1 percent in 'price' in foreign currency, securities, gold, and special drawing rights, for instance, will reduce the quantity of corresponding foreign reserves demanded, ranging from 0. 08 to 0. 89 percent, ceteris paribus. The highest own-price elasticity of securities is reasonable. The yield of securities is the most volatile compared to the price of other foreign reserves. Moreover, the securities reserve holding is dominant, resulting in the central bank being more sensitive to the change in securities yields.

Overall, the results of this research are not in line with most previous studies as outlined in the literature review section, such as Prabheesh *et al.*(2007), Molapo and Thamae (2015), Sooriyan (2017), Azeem and Khurshid (2019), and Islam (2021), However, our results support the studies of Sinem and Nebiye (2014), Sanusi *et al.*(2019), Rashid and Basit (2021), and Tran and Le (2020). It seems that differences in measuring foreign reserve prices offer different conclusions. The advantage of this study is that it uses many foreignreserve pricess imultaneously, so the results of this research can reconcile the differences in the results of previous studies.

Furthermore, the wealth elasticity with respect to gold, on the one hand, is the lowest, 0. 14. This result is somehow surprising. An increase of 1 percent in wealth is associated with an increase in the allocation of gold reserves by an average of 0. 14 percent only. The similar result is found in the case of special drawing rights. In fact, the gold and special drawing rights prices are the most stable relative to the prices of other foreign reserves and the proportion of monetary gold and special drawing rights reserve holdings are quite small. Given this result, the central bank seems to consider that the monetary gold reserve is rather a necessary need, which is less sensitive to the change in wealth.

On the other hand, the effect of wealth on the securities reserve holding is highest, 1. 13. An increase of 1 percent in wealth induces the change in the central bank's securities reserve holding for about 1. 13 percent. This result is consistent with the own-price elasticity. The highest own-price elasticity is followed by the highest of wealth elasticity. It means that the central bank is very responsive to the global economic performance in terms of return and risk (Božanić *et al.*, 2023). Therefore, the securities reserves seem to have the potential to be reset in the near future. In the medium-long runs, the increase in uncertainty demands a more optimal mix of foreign exchange reserves and securities.

Overall, the wealth elasticity is positive for all four cases. The positive wealth elasticity index exhibits that the central bank's allocations on foreign currency, securities, gold, and special drawing rights move along the line of the income consumption curve (ICC). The ICC represents in the case that all foreign reserve prices are held constant, any increase in wealth will encourage the demand for all of the four foreign reserves. The effects that lead to the changes in the amount of foreign reserves held since the central banks move along the line of the new ICC to a higher level, which means the same expenditure, is well-known as the expenditure effect (Varian, 1992). In other words, the Engle curve is observable, depicting the demand for foreign reserves as a function of income so that mercantile motives hold.

Table 5. AIDS: Own-Price, Cross-Price, and Wealth Elasticity

	C	B	G	S	Z/P
C	-0. 3085	-0. 0903	0. 0134	0. 0174	0. 3679
B		-0. 9807	-0. 0354	-0. 0227	1. 1348
G			-0. 0850	-0. 0066	0. 1435
S				-0. 1488	0. 1624

Note: See Table 1

Source: Authors' work

So far, we have examined the price and income elasticity individually. Table 5 also highlights the cross-price elasticity for all four types of foreign reserves. The cross price elasticity of foreign currency with respect to securities appears to be negative (-0. 09). This result suggests that a depreciation of domestic currency relative to securities' yield will induce substantial expansion in the securities reserve, thereby offsetting or even outweighing the adverse impact of the depreciation of domestic currency on the foreign currency reserves demand. Hence, the negative impact holds, i. e. the foreign currency reserves demand is substitutable for securities reserves holding.

Conversely, the cross-price elasticity of foreign currency reserves with respect to gold and special drawing rights reserves shows a positive sign, 0. 01and 0. 02 respectively. Merely referring to the positive sign of the corresponding variable, it can be said that the foreign currency and gold and the foreign currency and special drawing rights are pairwise complementary. Nevertheless, they are even independent of each other when we consider the statistical results from the structural model. It implies that an increase in exchange rates that makes foreign currency holding cost reduction will not generate a large positive effect on the gold and special drawing rights reserves holding, that falls behind the substitution effect. They lead to a simultaneous contraction in securities holding that further reduces international reserves. These prognostications about the two kinds of reserves holding' reaction to foreign currency appear to be in line with what we have detected in the post commodity boom.

To confirm our findings, we perform a robustness test. As a validity test, we re-estimate the EC-AIDS model as equation (12) by incorporating a dummy variable to capture the pandemic Covid-19 (2020 = 1, others= 0). Unfortunately, the corresponding coefficient of the additional dummy variableis insignificant (see: Appendix). The result does not alter the main conclusion that opportunity cost plays an important role in foreign reserves. Those results are consistent with the unit roots tests. Despite structural breaks present, the foreign reserves growth is stable in accordance with a disequilibrium process. Accordingly, our conclusions are robust, independently of the explanatory variables to be used in the econometric model.

The substitution, complementary, and independent relationships among pairwise foreign reserve components indicate that the precautionary motives hold. They implicitly suggest further there is achance for foreign reserves restructuring policy. Hence, foreign exchange reserves restructuring policy is feasible for Indonesia to run foreign exchange rate market stabilisation more along with avoiding substantially the high opportunity cost of holding other reserves. The increase in foreign exchange rates does not immediately induce the central bank to intervene in the market, which could impact the international reserves level. The increase in foreign exchange rates cannot be accompanied by the increase in the securities yields. In contrast, the increase in foreign exchange rates may be compensated by the increase in gold and special drawing rights holdings. In the case of Indonesia, where the international reserves are dominated by securities holding, the foreign exchange reserves restructuring policy should remove them so the central bank is flexible-to-recompose.

5. CONCLUSION

This paper models the behaviour of foreign reserves holding in the case of Indonesia. The foreign reserves holding extends foreign currency, securities, gold, and special drawing rights. Different from the previous studies, the four reserves are assessed using a system-wide approach to consumption economics. The Almost Ideal Demand Systemproposed by Deaton and Muellbauer (1980) combined by Engle and Granger's (1987) two-steps Error Correction Model is employed to test whether the conventional theory of demand holds. Applying on the monthly data during 2010-2020 in the case of Indonesia, we find that the basic theory of demand behaviour is generally acceptable.

The results indicate that the wealth elasticity for securities holding is larger than unity whereas that for other foreign reserves is less than unity. As expected, the own-opportunity cost coefficients are negative and statistically significant. The own-opportunity cost elasticities for foreign currency, securities, gold, and special drawing rights in the short run are -0. 31, -0. 98, -0. 08, and -0. 15 respectively. The cross-opportunity cost elasticities mostly are negative, representing that the pairwise reserve component is substitutive. The cross-opportunity cost elasticities of foreign currency-gold pairwise and foreign currency-special drawing rights pair are positive, suggesting that the two pairwise reserves are complementary or even independent.

The own- and cross-elasticity estimates of this study will be useful for monetary policy formulation. The central bank of Indonesia might rebalance its portfolio. Since the proportion of securities holding is the highest, the central bank of Indonesia can switch it to foreign currency, gold, or special drawing rights. Accordingly, the central bank of Indonesia can conduct exchange rate stabilisation (as the main task) more without substantially losing the returns. In other words, by substituting parts of securities into foreign currency, for example, the central bank of Indonesia remains having an optimal level of reserves holding in terms of its opportunity cost.

Further research is advisable to pay more attention to the foreign currency and securities reserves. The reserves holding reveal an overweight in securities whose different maturity. Apart from the US Dollar, the foreign currency reserves consist of many other foreign currencies. Data on the foreign currency and maturity of the securities breakdown of central banks' balance sheets is confidential, precluding any formal analysis of the behavioural model of foreign exchange reserves holding.

ACKNOWLEDGMENT

This work was financially supported by the Faculty of Economics and Research and Community Service Institution (LPPM) State University of Jakarta, Indonesia.

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APPENDIX

Extended EC-AIDS Model with Dummy Covid-19

Dependent Variable	Independent Variable	AIDS		
		Coeff.	SE	Prob.
Δ SC	Δ PC	0. 0697	0. 0285	0. 0150
	Δ PB	-0. 0690	0. 0268	0. 0103
	Δ PG	-0. 0007	0. 0028	0. 8126
	Δ PS	0. 0000[a]	0. 0049	0. 4732[e]
	Δ Log Z/P	-0. 0697	0. 0272	0. 0108
	EC(-1)	-0. 1669	0. 0327	0. 0000
	DCOV	-0. 0059	0. 0043	0. 1663
Δ SB	Δ PC	-0. 0690	0. 0268	0. 0103
	Δ PB	0. 1117	0. 0263	0. 0000
	Δ PG	-0. 0260	0. 0028	0. 0000
	Δ PS	-0. 0167[a]	0. 0356	0. 0000[e]
	Δ Log Z/P	0. 1133	0. 0268	0. 0000
	EB(-1)	-0. 1577	0. 0341	0. 0000
	DCOV	0. 0048	0. 0041	0. 2420
Δ SG	Δ PC	-0. 0007	0. 0028	0. 8126
	Δ PB	-0. 0260	0. 0028	0. 0000
	Δ PG	0. 0276	0. 0015	0. 0000
	Δ PS	-0. 0009[a]	0. 0023	0. 0968[e]
	Δ Log Z/P	-0. 0265	0. 0028	0. 0000
	EG(-1)	-0. 2303	0. 0517	0. 0000
	DCOV	0. 0006	0. 0003	0. 0626
Δ SS	Δ PC	0. 0000[a]	0. 0049	0. 4732[e]
	Δ PB	0. 0167[a]	0. 0356	0. 0000[e]
	Δ PG	-0. 0009[a]	0. 0023	0. 0968[e]
	Δ PS	-0. 0158[b]	0. 0088	0. 0148[g]
	Δ Log Z/P	-0. 0171[c]	0. 0046	0. 0001[f]
	ES(-1)	-0. 1211[f]	0. 0595	0. 0424[f]
	DCOV	0. 0003	0. 0004	0. 4951

Note: See Table 4

ECONOMICS
Innovative and Economics Research Journal
Volume 12, No. 1, 2024
www.economicsrs.com

SUSTAINABLE DEVELOPMENT AND COMPETITIVENESS: IS THERE A NEED FOR GCI RECONSTRUCTION?

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Received 23.11.2023. | Sent to review 04.12.2023. | Accepted 29.03.2024.

Original article

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JEL Classification: O10, O19

Doi: 10.2478/eoik-2024-0001

UDK: 502.131.1:316.334.5

ABSTRACT

Starting from competitiveness as the ability of an entity (company, sector, state) to successfully increase sales on the domestic and/or international market, and through a balance surplus to create growing revenues for its company and/or residents, i.e. the entire country, the concept of competitiveness should be transformed according to today's business conditions. Competitiveness was initially related to cost, and sales grew due to lower product prices, and later due to productivity and better product quality. Today's consumer is not only interested in price and quality, but also in environmental sustainability and social responsibility, and customers are looking for sustainable products. This paper investigates the relationship between the Global Competitiveness Index (GCI) and the Sustainable Development Goals (SDG) index on a sample of 27 member states of the European Union in the period 2007-2017, with the main goal and purpose of determining the direction and strength of the relationship and creating a platform for the necessity of redesigning the GCI. The impact of climate change on the GCI was examined by the Sustainable Development Index. For this purpose, Difference GMM was used. The results show that SDG12 (waste generation) hurts competitiveness, while SDG14 (maritime, ocean conservation) has a positive impact on competitiveness. This study contributes to the ongoing discourse on the intersection of competitiveness and sustainability, providing a foundation for future discussions and potential reconstructions of indices that reflect the changing global environment.

Keywords: *competitiveness, sustainable development, GCI index, SDG index, European Union*

1. INTRODUCTION

For many years, economic growth has not been the mainly priority of national economies, but sustainable growth, and the most widespread definition of that is ""development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations General Assembly, 1987). The United Nations (UN) adopted the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs) in September 2015 as the world's roadmap for achieving sustainable development in this decade. The 2030 Agenda is a key document for the development of long-term economic strategies and roadmaps.

Some SDG goals are included indirectly in the calculation of the Global Competitiveness Index, while the environmental impact does not have a specific position in the methodology. In terms of climate impact as a result of poor environmental policies, financial losses from weather- and climate-related hazards would continue to rise. In this paper, authors investigate the relationship between climate change and competitiveness.

This paper is divided into six sections. Following the introduction, the first section covers the theoretical underpinnings of competitiveness at three different levels: micro, macro, and international. The "green transformation" of the European economy is examined in the third section, which also discusses the connection between green transformation and competitiveness. After a description of the data, outcomes, and methods, conclusions are made in the last part.

2. THEORETICAL APPROACH OF COMPETITIVENESS - MICRO, MACRO AND INTERNATIONAL REVIEW

Competitiveness is a very old term that has been attracting the attention of economists for hundreds of years, as well as a multidimensional category that is observed at different levels. Competitiveness is viewed through individual activities, at the level of a sector or company (micro), but also at the overall national economy (macro level). Globalization enables competitiveness at the international level. According to Škuflić (2005), competitiveness is examined at the micro, macro, and mezzo level, but it is always assessed how well some entity or state (which represents the sum of its entities) is able to sell its products and services on the domestic or international market, i.e., whether its importance is increasing or decreasing. Competitiveness, in general, can be defined as the ability to face competition on the world market, i.e., the ability to survive in the existing one and conquer new markets (OECD, 1998).

At the micro level, competitiveness is usually equated with a company's market success, i.e., the dynamics of market share and positioning on the quality scale. At the macro level, competitiveness is a wider concept that encompasses growth, quality of life, and productivity. Foreign markets revenue generation necessary for improvement in the quality of life and standards of living, is only possible with competitive products, encompassing micro, macro, and international competitiveness.

At the beginning, competitiveness has been primarily connected with the costs of firms or countries, emphasizing wages as well as unit labour costs and productivity as main determinants. It is still often used today when new low-cost competitors enter to the (or a firm or industry), a concept mostly criticized by Krugman (1994A, 1994B). Concepts of price competitiveness viewed through the level of costs or in a broader approach (looking at costs and productivity through unit labor costs) become complicated when it is necessary to analyze all cost components (labor, capital, energy, taxes) together with all productivity components. Therefore, in recent literature, economists have investigated total factor productivity (Aigniger et al., 2013).

Definitions of competitiveness vary. According to Šegota, Tomljanović, and Huđek (2017), long-term competitiveness involves an increase in economic efficiency and product quality, which is vital for improvement of the living standards. However, the competitiveness of enterprises in domestic and international markets depends on their capabilities and costs. Fagerberg (1988) notes that competitive countries not only increase real income but also create new jobs; hence, competitiveness is defined as the achievement of economic objectives (income and employment growth) with the prevention of a current account deficit. Additionally, Lovrinčević et al. (2008) highlight that globalization heavily influences competitiveness, requiring a global perspective to compete with competitors worldwide, emphasizing high-value sectors and production.

2. 1. MICRO APPROACH TO COMPETITIVENESS

The micro approach to competitiveness focuses on measuring the competitiveness of individual companies, industries, and sectors. The competitiveness of an individual company can be measured in various ways, depending on the sector in which it operates, the size of the company, and other factors. When measuring competitiveness at the micro level, costs, sales, product quality, innovation, and human resources are the most commonly analyzed factors.

Krugman (1996, 1994) represents the extreme view according to which competitiveness is not applicable at the country level but only at the enterprise level. However, significant differences in economic development across countries at similar stages of economic development indicate the existence of successful and less successful countries. Porter (1990) is one of the most well-known authors who researched competitiveness from a micro perspective. He developed the concept of competitive strategy based on the analysis of five forces: the power of buyers, the power of suppliers, the threat of new entrants, the threat of substitute products, and competition among existing firms. Porter emphasized the importance of product and service differentiation and focusing on narrow market segments to achieve a competitive advantage.

Teece, in his 2014 study, highlighted the importance of a company's dynamic capabilities, i.e., its ability to quickly adapt to changing market conditions and actively pursue new opportunities. According to Teece, companies with high levels of dynamic capabilities are able to develop innovative products and services and successfully navigate market changes. Markides and Williamson (2018) researched competitiveness from the perspective of management strategy. They emphasized the importance of integrating management strategies to achieve a competitive advantage, including human resource strategy, production strategy, and marketing strategy. Barney and Hesterly (2015) focused on the role of resources and capabilities in achieving a competitive advantage. They emphasized the importance of managing a company's resources, such as human resources, technological resources, and financial resources, to achieve a competitive advantage.

The main conclusions of research on competitiveness from a micro perspective are that companies with high levels of competitiveness usually have a clearly defined strategy and vision, effective resource management, innovative products and services, a focus on quality and customer experience, and the ability to quickly adapt to changing market conditions. The importance of analyzing a company's environment, as well as analyzing its own strengths and weaknesses, is key to developing a competitive strategy.

In summary, the competence of an organization or country to produce and sell products/services that meet the quality of the markets at the same or lower prices and maximize returns on the resources consumed in producing them (Maravilhas, S., Oliveira, S. G. 2018).

2. 2. MACRO APPROACH TO COMPETITIVENESS

The macro approach to competitiveness focuses on measuring the competitiveness of an entire country or region, rather than individual firms. The macro approach encompasses a broader set of economic, political, social, and institutional factors that affect a country or region's ability to achieve high levels of economic growth, improve the quality of life of its citizens, and attract foreign investment. In the first OECD materials, competitiveness was divided into import, export, and overall competitiveness. In subsequent years, in the literature, can be found price and quality competitiveness, while in 2013, Karl Aiginger, Susanne Bärenthaler-Sieber, and Johanna Vogel divided competitiveness into price, quality, and outcome competitiveness. Therefore, initially, competitiveness focused on factor costs and productivity, and later on product quality. Quality competitiveness is focused on structure and capabilities, while outcome competitiveness, according to the European Commission (2001), means "the ability of an economy to provide its population with high and rising standards of living and high rates of employment on a sustainable basis." Two main indicators used for outcome competitiveness are GDP per capita and unemployment indicators or sometimes employment. In this concept, social and environmental aspects have an important role.

M. Porter (1990) was the first economic theorist to define the concept of competitiveness at the macroeconomic level. As each country aims to achieve growing and high living standards for its citizens, the productivity of production factors is significant for the full realization of this goal. This means that it is necessary to distinguish between national economic competitiveness and firm competitiveness. Porter's (Porter, 1990) research showed that national competitiveness is created by the interaction of: 1) factor conditions, 2) strategy, structure, and rivalry among firms in the industry, 3) quality of domestic demand, and 4) the existence of a group (cluster) of related supporting industries in the country. Government policy and actions have an impact on competitiveness.

Deepening Porter's insights, Lovrinčević et al. (2008) mention Trabold's four significant aspects of competitiveness: the ability to sell on the global market (export), the ability to attract investment (location), the ability to adapt the economy, and the ability to create and increase disposable income. They conclude that these different aspects constitute a certain hierarchy. Thus, the ability to achieve and increase disposable income, which is most often measured by GDP growth, is a broad indicator of the country's competitiveness. The mentioned indicator depends on the other three elements, each of which is an independent aspect of competitiveness. According to this definition, three derived elements of competitiveness are directly measurable at the national level (GDP growth, export growth, and inflow of foreign direct investment). The speed at which the economy responds to changes in market conditions is difficult to be represented by only one indicator as well as the possibility that the economy recognizes new opportunities and economists use several indicators. In some analyses, competitiveness is sometimes depicted by data on the value of the research and development sector. These macroeconomic indicators, which according to theoretical works indicate the level of competitiveness encountered, are called "hard" statistical indicators in the work because they are available from standard statistical surveys conducted in all countries.

Recent macro-level competitiveness research has focused on different factors that affect national competitiveness. One such study (Kaplinsky, 2020) focused on the impact of global value chains on national competitiveness. The authors concluded that nations that are integrated into global value chains have greater competitiveness and higher growth.

Hausmann and Hidalgo (2014) developed the concept of economic complexity, which measures a country's ability to create complex products based on its production structure. Their research shows that economic complexity is a key factor in the long-term economic growth and competitiveness of a country. The World Economic Forum (WEF, 2017.,p. 20) defines competitiveness as "the set of institutions, policies, and factors that determine the level of productivity of a country" and publishes an annual report on global competitiveness that evaluates the competitiveness of countries based on 12 pillars. The latest report for 2021 shows that the most competitive countries are Switzerland, the United States, and Singapore. The WEF methodology for measuring the competitiveness of countries consists of 12 "pillars" that relate to different areas important for economic competitiveness. Under these pillars are three categories: basic requirements, efficiency enhancers, and innovation and sophistication factors. The basic factors category covers institutions, infrastructure, macroeconomic environment, health, and primary education and they form the foundation of factor-driven economies. The second group of pillars in the efficiency enhancers category include higher education and training, goods market efficiency, labor market efficiency, financial market development, technological readiness, and market size and presents form the foundation of efficiency-driven economies. The last group of pillars in the innovation and sophistication factors category include business sophistication and innovation.

Data for each of these pillars are collected from various sources such as surveys of business people, statistical data, and other sources. The collected data are analysed and processed to produce a final competitiveness index for each country. The index is calculated on a scale from 0 to 100, with higher values indicating greater competitiveness.

The special edition of the WEF Global Competitiveness Report for 2020 focused on analyzing the impact of the COVID-19 pandemic on the competitiveness of countries worldwide. The report concluded that the pandemic significantly affected global competitiveness by reducing economic growth and worsening the business environment. Countries that effectively managed the pandemic, such as South Korea, Singapore, and Taiwan, were able to maintain a high level of competitiveness. The report also highlighted the importance of digitalization in maintaining competitiveness during the pandemic, with a focus on technologies like artificial intelligence, blockchain, and the Internet of Things. Additionally, the report noted that countries prioritizing green transition and sustainable development demonstrated greater resilience during the pandemic. The report emphasized the need for strengthening global cooperation and solidarity to mitigate the pandemic's impact and support the recovery of the world economy.

However, according to a study conducted by Šegota, Tomljanović, and Huđek (2017), the Global Competitiveness Index (GCI) may be an incomplete measure for ranking countries' macroeconomic competitiveness as it overlooks the efficiency of utilizing multiple inputs to achieve multiple outputs. The study suggests utilizing Data Envelopment Analysis (DEA) to evaluate the relative efficiency of countries, which could affect the final ranking.

In conclusion, a country's level of competitiveness depends on various factors, including the quality of institutions, education and expertise of the workforce, technological development, stability of the political environment, availability of capital, and quality of infrastructure, among others. Competitive countries typically possess quality public institutions, clear policies, a transparent and stable business environment, innovative and productive companies, and a high-quality education system. Achieving high competitiveness in the global exchange is not a static state but requires continuous improvement, technical and technological advancement, adaptation, and high flexibility within the entire economic system.

2. 3. INTERNATIONAL COMPETITIVENESS

The modern global economy, small or large, faces increasing interconnectedness through the exchange of goods and services, but also through the movement of capital and labor flows. The liberalization of international trade and financial flows, along with contemporary and affordable channels of distribution, significantly redefines competitiveness. Competitiveness, by definition, increasingly requires an international perspective, as countries need to compete with rivals from any region of the world. In addition to the World Economic Forum (WEF) methodology for determining competitiveness at the macro and international levels, there are several other methodologies and indicators used to assess international competitiveness. Some of the most commonly used methodologies include the following: 1) IMD World Competitiveness Index:

This index focuses on companies and their ability to compete in the global market. It consists of four categories: economic performance, infrastructure, business environment, and knowledge. 2) Doing Business Index: This index focuses on the business environment and regulations in countries. It consists of ten categories that measure a country's ability to facilitate business. 3) UNCTAD Export Competitiveness Index: This index focuses on countries' ability to export to the global market. It consists of five categories that measure competitiveness in exports. Indicators used in these methodologies include but are not limited to, the quality of infrastructure, business climate, education system, quality of institutions, innovation, macroeconomic environment, business costs, tax and regulatory levels, availability of financing, labor market conditions, and other relevant aspects for economic competitiveness.

Since 2012. the Global Sustainable Competitiveness Index (GSCI) has been calculated and tracked. It measures the competitiveness and sustainability of countries, based on 190 quantitative indicators derived from international organizations (World Bank, IMF, UN). This Index is a more recent indicator and seeks to reconcile competitiveness and sustainable development. The main determinants of that index are the ability to create and maintain inclusive wealth and a standard of living for all citizens in a globalized world. It consists of 6 related elements: natural capital (the given natural environment and climate, minus human-induced degradation and pollution), social capital, intellectual capital (the ability to compete in the globalized market through sustainable innovation), resource management (the ability to extract the greatest possible value from existing resources (natural, human, financial) and governance (the framework given, usually by government policies and investments, in which a national economy operates). Sustainable competitiveness means the ability of a country to meet the needs and basic requirements of current generations while sustaining or growing the national and individual wealth into the future without depleting natural and social capital (GSCI, (https://solability.com/the-global-sustainable-competitiveness-index/the-index). Sweden is the leader in the Sustainable Competitiveness Index in 2022, followed by Iceland, Denmark, and Finland, while Norway is in 9th place and Germany in 15th. Between top 20 countries, all belong to Northern Europe and Baltic countries.

3. GREEN TRANSITION OF THE EUROPEAN ECONOMY

The green transformation began in the mid-twentieth century, but it became more intensely focused after the Kyoto Protocol, though some significant initiatives were signed even before that. The United Nations Framework Convention on Climate Change (UNFCCC) was established in 1992 to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference in the climate system (UNFCCC, 1992)..

The environment is Earth's most valuable resource, and it has been under attack since the dawn of industrialization. Because the environment is a relatively non-renewable resource that has been poorly managed, the consequences are visible and are being paid for on a daily basis through climate change. Rainfall changes, frequent droughts, rising sea levels, and melting glaciers are just a few of the issues affecting the world economy today. Numerous floods, tornadoes, severe droughts, and other natural disasters cause financial and human losses. Some countries, particularly island countries, are more vulnerable than others due to their geographical location, regardless of how much they have contributed to environmental clean-up. Specifically, the consequences of environmental problems affect everyone, not just poor countries.

Since the industrial revolution, greenhouse gas (GHG) emissions, mainly carbon dioxide (CO2), have increased, causing an intensified greenhouse effect and ultimately leading to global warming (climate change). The process of industrialization occurred significantly faster in developed countries, and they have contributed more to greenhouse gas emissions compared to less developed countries. However, over time, they have attempted to regulate this issue within their own countries and beyond, resulting in the relocation of polluting industries from developed to less developed countries. Polluters in consumption, in addition to polluters in production, are most prevalent in developed countries, primarily car drivers. Energy, industrial processes, product use, agriculture, forestry, land use, and waste are the sectors with the highest GHG emissions (IPCC, 2006).

Mbarek M.B.& all. (2016) examine the long-term causal relationship between renewable energy, CO2 emissions, and economic growth in the four Mediterranean countries; including France, Spain, Italy, and Turkey over the 1980–2012 period. The results of Pedroni and Kao co-integration tests indicate a long-term relationship between these variables. This finding has vital consequences regarding energy and economic policy, as it suggests that renewable energy use do not seem to damage economic growth and development in these countries. The importance of including social responsibility and corporate governance to strengthen the competitiveness of companies, as well as to encourage their flexibility, research was conducted by Kuzmak and Kuzmak (Kuzmak and Kuzmak, 2023) on the economy of Ukraine. In addition to the inclusion of environmental, social and governmental goals in the evaluation of the state's performance, some authors have investigated this at the macro level as well as at the sectoral level. In their paper, Mastilo et al. (Mastilo et all, 2024) gave the literature review on the importance of the relationship between the environment and social responsibility, and the financial position and reputation of banks.

Although the greenhouse effect occurs naturally, human activities such as industrialization contribute to global warming and the associated temperature, humidity, wind speed, rainfall, soil dryness, and sea level anomalies.

3. 1. GLOBAL INITIATIVES

The Paris Agreement, Sustainable Development Goals, Task Force on Climate-Related Financial Disclosure, and United Nations Environmental Program Finance Initiative are the most important and influential global initiatives after the Kyoto Protocol, among others.

The Paris Agreement is a legally binding international treaty on climate change that was adopted by 196 Parties (but ratified by 189) at the United Nations Climate Change Conference (COP21) in 2015 but did not enter into force until 2016. Its primary goal was to keep "the increase in global average temperature to well below 2°C above pre-industrial levels," but in recent years, world leaders have emphasized the importance of keeping global warming to 1.5°C by the end of this century (UN, 2015). The lower threshold is the result of research conducted by the UN Intergovernmental Panel on Climate Change, which revealed that exceeding the 1.5 °C threshold risks unleashing much more severe climate change effects, such as more frequent and severe droughts, heat waves, and precipitation (UN, Climate Change). The Paris Agreement establishes a long-term framework for global efforts for decades to come. It is the first step toward achieving net-zero emissions. The Agreement's implementation is also critical for achieving the Sustainable Development Goals. Climate Action (United Nations).

The 2030 Agenda for Sustainable Development, adopted by the members of the United Nations in 2015, is a joint platform for peace and prosperity for both people and the planet, now and in the future. At the center of that platform are 17 Sustainable Development Goals (SDGs), aiming to end poverty and improve health and education, and reduce inequality and achieve sustainable economic growth, which requires a healthy environment without climate change. Those 17 goals are (UN, 2015): 1. End poverty in all its forms everywhere; 2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture; 3. Ensure healthy lives and promote well-being for all at all ages; 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all; 5. Achieve gender equality and empower all women and girls; 6. Ensure availability and sustainable management of water and sanitation for all; 7. Ensure access to affordable, reliable, sustainable, and modern energy for all; 8. Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all; 9. Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation; 10. Reduce inequality within and among countries; 11. Make cities and human settlements inclusive, safe, resilient, and sustainable; 12. Ensure sustainable consumption and production patterns; 13. Take urgent action to combat climate change and its impacts; 14. Conserve and sustainably use the oceans, seas, and marine resources for sustainable development; 15. Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and biodiversity loss; 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels and 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development. Some of the 17 goals are applicable exclusively at the state level, but some of the goals can and are implemented in the company's operations. Following global initiatives such as the OECD Guidelines for multinational enterprises, many countries have adopted legal regulations for company operations in their country. The OECD Guidelines for Multinational Enterprises are recommendations addressed by governments to multinational enterprises operating in or from adhering countries. They provide non-binding principles and standards for responsible business conduct in a global context consistent with applicable laws and internationally recognized standards. The Guidelines are the only multilaterally agreed and comprehensive code of responsible business conduct that governments have committed to promoting (OECD, 2011)

3. 2. THE EUROPEAN GREEN DEAL

The European Green Plan brings a strategy for making the EU's economy more sustainable due to the climate and environmental risks and transforming risk into opportunities across all policy areas. This plan ensures a just and inclusive transition for economies. The EU is attempting to overcome risks by transforming them into opportunities through the Green Plan. The EU aims to promote resource efficiency through the use of clean energy, a circular economy, and the prevention of environmental destruction and climate change, as well as to reverse biodiversity loss and reduce pollution. The circular economy, encompassing the social, environmental, and economic facets of sustainable development, presents a viable solution to mitigate the resource constraints and socio-environmental ramifications inherent in the prevailing linear economic model (Lin and Wei, 2023).

The European Union (EU) has fully committed to achieving the goals of the 2030 Agenda, which are reflected in numerous European working plans and roadmaps. Eurostat has been producing annual reports on the EU's progress toward the SDGs since 2017. This 2022 edition is the sixth in the series, analyzing the EU's progress toward the goals using the official EU SDG indicator set (Sustainable Development in the EU 2022, EC). The Green Deal Industrial Plan boosts Europe's net-zero industry's competitiveness while also hastening the transition to climate neutrality. It accomplishes this by fostering a more conducive environment for increasing the EU's manufacturing capacity for the net-zero technologies and products required to meet Europe's ambitious climate targets.

Although SDG goals are important for the country's overall economic growth and development, authors believe that some goals should be prioritized over others to achieve a sustainable level of competitiveness. Objectives that are important but underrepresented in the competitiveness index are highlighted. These are objectives 6,7,8,13,14,15. Regarding the previously identified goals that should be included in the competitiveness assessment, the EU made the most progress in reducing electricity consumption and switching to renewable energy sources, which is encouraging given that the energy sector emits the most CO2 into the atmosphere. While the EU has already reduced its net greenhouse gas (GHG) emissions by about 31% since 1990, further progress will be required to meet the new 55% reduction target for 2030, especially given that GHG emissions are expected to rise again in 2021 as the economy recovers. Clean water, sanitation, and life on Earth have made the slowest progress. (EC, Sustainable Development in the EU 2022).

3. 3. COMPETITIVENESS AND CIRCULAR ECONOMY

As stated in the theoretical section of this paper, competitiveness is linked to profits on the micro level as well as national income on the macro level. Being competitive entails creating a marketable product, conquering the market better and faster than competitors, and increasing market share. Nowadays, when consumer awareness is changing and more and more efforts are being made to change through marketing activities, being competitive means producing a product that is in harmony with nature and does not harm nature in any of its production or consumption segments. Thus, competitiveness in recent times means a product that uses recycled inputs in its production, a product that has a complete plan from production to consumption to disposal, and a product that can be re-entered into production at the end of its useful life. Of course, it is critical to reduce the use of electricity as well as water in the manufacturing process to achieve the smallest possible water and carbon footprint in both production and consumption. A circular economy entails reusing resources, extending the life of products, and ensuring proper disposal after use.

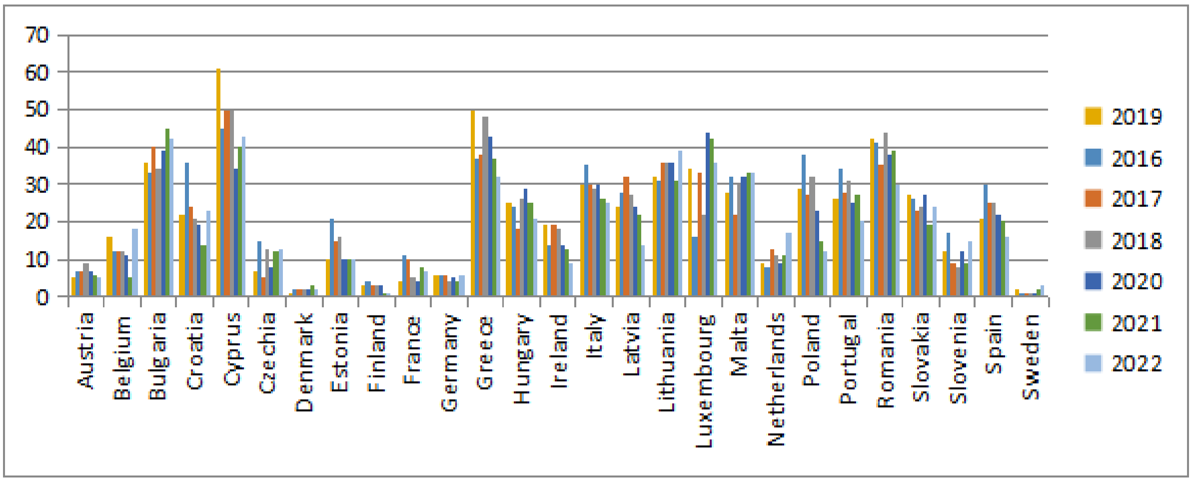
The Green Deal also includes the Circular Economy Package, which was adopted to increase global competitiveness, foster sustainable economic growth, and create new jobs. The Circular Economy Package is divided into two parts: first, EU Action Plans for the Circular Economy, with measures covering the entire product life cycle: from production and consumption to waste management and the market for secondary raw materials. The second section focuses on resource-intensive sectors with a high potential for circularity, to keep resources in economic cycles for as long as possible (European Commission, The EU Switch to Green Flagship Initiative).

3. 4. SDG INDEX

In 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development, with the goal of eradicating poverty in all of its forms. The United Nations 2030 Agenda envisions "a world of universal respect for human rights and human dignity, the rule of law, justice, equality, and non-discrimination," and the Agenda's 17 Sustainable Development Goals (SDG) and 169 targets aim to eradicate poverty in all forms and "seek to realize the human rights of all and achieve gender equality." (According to the Council of Europe, https://www.coe.int/en/web/programmes/un-2030-agenda). Since 2015, the UN has published the new indicator SDG index, which ranks countries and assigns a monetary value to them. The EU countries are ranked in terms of achieving the SDGs in the table below.

Sweden, Finland, and Denmark improved the most in terms of achievement of the 17 goals, followed by Germany, France, and Austria, with Cyprus, Greece, Romania, and Bulgaria faring the worst (figure 2). Luxembourg is a surprise among EU countries; despite being highly developed; the SDG index ranks that country among the bottom in terms of sustainability goals.

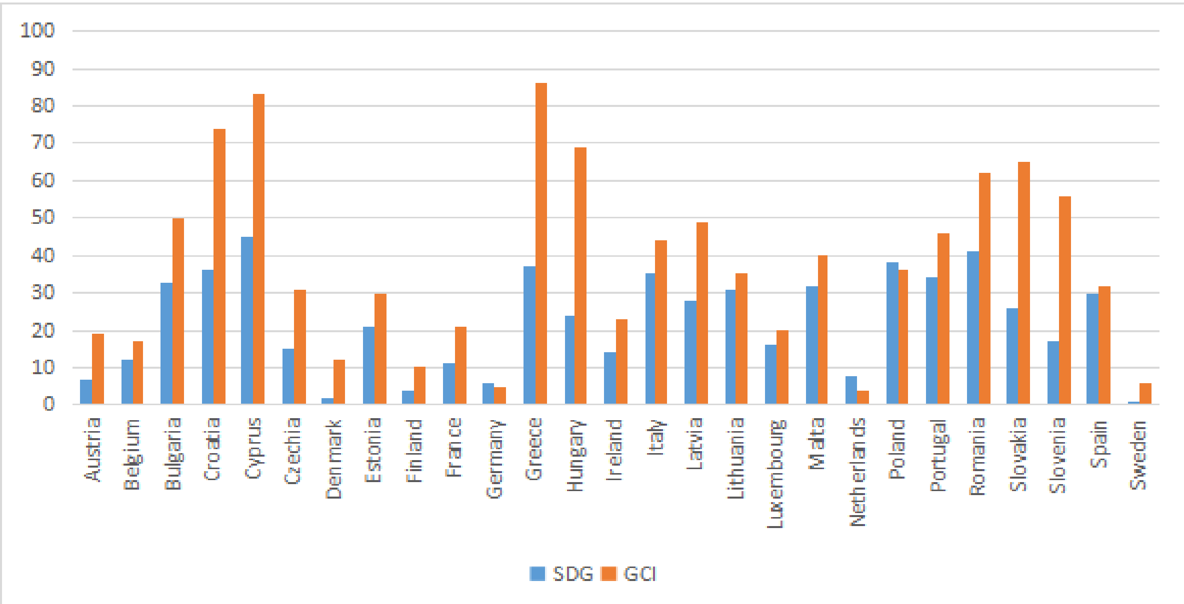
Figure 1. SDG index ranks the EU countries, 2015-2022



Source: https://www.sdgindex.org

According to the achieved level of competitiveness as measured by the competitiveness index and the rank on the scale of achieved SDG goals, a significant disparity was observed in 2016, specifically in countries with a lower level of competitiveness. It can be conclude that a country with a higher level of competitiveness achieves better results in terms of poverty reduction, human rights, discrimination elimination, and so on, whereas this problem is much more pronounced in countries with a lower level of competitiveness. Croatia, Cyprus, Greece, Hungary, Romania, Slovakia, and Slovenia had the greatest disparity in 2016, while Germany and the Netherlands had the smallest.

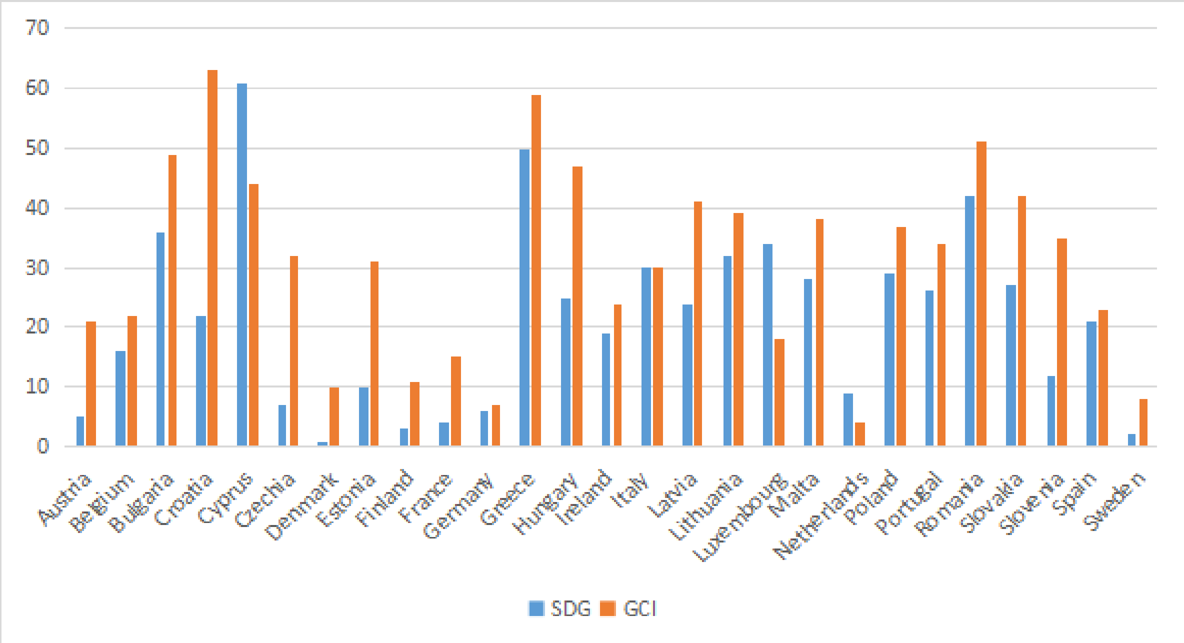
Figure 2. SDG and GCI rang for the EU countries, 2016



Source: https://www.sdgindex.org and https://ww.weforum.org/reports?utf8=✓&query=global+competitiveness+report

The analysis of these two indicators in 2019 (the most recent year for which the GCI index was available) revealed a significant difference for Croatia, the Czech Republic, Hungary, Estonia, and Slovenia, with Germany having the lowest.

Figure 3. SDG and GCI rang for the EU countries, 2019



Source: https://www.sdgindex.org and https://www.weforum.org/reports?utf8=✓&query=global+competitiveness+report

Based on the data presented thus far, it can be conclude that a lower level of competitiveness is associated with lower success in addressing poverty, hunger, discrimination, and other sustainability goals. Furthermore, taking into consideration the GCI's composition and its 12 pillars, there is insufficient data on environmental and climate changes, which have a huge impact on poverty, hunger, and other sustainability issues through extreme weather changes and disasters with huge hazards and catastrophic consequences. In accordance with the foregoing, the paper investigates the relationship between environmental protection and the level of competitiveness using appropriate regression models.

4. INCLUSION OF „GREEN" COMPONENTS IN THE CALCULATION OF THE GLOBAL COMPETITIVENESS INDEX

Climate change is primarily caused by the emission of greenhouse gases, as well as environmental and water pollution, as previously stated. The global competitiveness index does not include any of the indicators evaluated through the 17 SDG goals. Taking everything into consideration, it is estimated that the existing index with 3 units and 12 pillars will need to be upgraded with one more unit, which is the impact on the environment, for which several pillars will need to be designed. The fourth unit could be called environmentally friendly economics, and it should consider several pillars:

- amount of drinking water consumed;
- electrical energy consumption and the share of renewable energy in total energy consumption;
- CO2 emissions;

- percentage of forested areas;
- total waste and percentage of recycled waste.

It should be noted that some of these indicators are included in the GSCI, but that index does not have elements of the GCI, so we believe that it is more correct to revise the GCI by adding one unit, than to define a new indicator from the ground up, as was done with the GSCI. Given that the aforementioned elements are largely incorporated into individual SDG goals, an econometric assessment will be performed in the following section of the work to determine whether there is a connection between individual SDG goals and GCI and how strong it is, if it exists. Because of their aggregation and multidimensionality, it is highly unlikely that the aggregated SDG targets will have a large explanatory power of the GCI.

5. DATA AND METHODOLOGY

The aim of this study was to examine how climate change affects competitiveness in the 27 European union member states. This study uses the variables depicted in the literature review section. Competitiveness is measured with the World Economic Forum's Global Competitiveness Index (GCI) obtained from Global Competitiveness Reports for the period 2007-2017. GCI score is provided only for the periods 2007-2017, afterwhich the methodology of the score calculation changed. Our research is, therefore, confined to the period 2007-2017.

Independent variables in the model are obtained from the United Nation's Sustainable Development Index. The United Nation's Sustainable Development Index is divided into 17 subindices. Each subindex encompasses several indicators that jointly compose the index score. Seven index scores of importance for this study correspond with the seven Sustainable Development Goals (SDGs): SDG6, SDG7, SDG8, SDG12, SDG13, SDG14 and SDG15. SDG6 index score incorporates the following measures: (i) share of population using at least basic sanitation services, (ii) share of freshwater withdrawals from available freshwater resources, (iii) share of anthropogenic wastewater that receives treatment, (iv) scarce water consumption embodied in imports (m3 H2O eq/capita), (v) share of population using safely managed water services, and (vi) share of population using safely managed sanitation services. SDG7 index score includes: (i) share of population with access to electricity, (ii) share of population with access to clean fuels and technology for cooking, (iii) CO_2 emissions from fuel combustion per total electricity output ($MtCO_2$/TWh), and (iv) share of renewable energy share in total final energy consumption. SDG12 index score is composed from: (i) municipal solid waste measured in kg per capita per day, (ii) electronic waste in kg per capita, (iii) production-based SO_2 emissions in kg per capita, (iv) SO_2 emissions embodied in imports in kg per capita, (v) production-based nitrogen emissions in kg per capita, (vi) nitrogen emissions embodied in imports in kg per capita, (vii) exports of plastic waste in kg per capita, and (viii) non-recycled municipal solid waste in kg per capita per day. SDG13 index score incorporates the following measures: (i) CO_2 emissions from fossil fuel combustion and cement production in tCO2 per capita, (ii) CO_2 emissions embodied in imports in tCO_2 per capita, (iii) CO_2 emissions embodied in fossil fuel exports in kg per capita), and (iv) Carbon Pricing Score at EUR60/tCO_2. SDG14 index score includes: (i) share of mean area that is protected in marine sites important to biodiversity, (ii) Ocean Health Index: Clean Waters score, (iii) fish caught from overexploited or collapsed stocks as a percentage of total catch, (iv) share of fish caught by trawling or dredging, (v) share of fish caught that are then discarded, and (vi) marine biodiversity threats embodied in imports per million persons. Finally, SDG15 index score is based on: (i) the share of mean area that is protected in terrestrial sites important to biodiversity, (ii) the share of mean area that is protected in freshwater sites important to biodiversity, (iii) Red List Index of species survival, (iv) permanent deforestation, and (v) terrestrial and freshwater biodiversity threats embodied in imports per million persons.

SDG8 index score is a control variable. SDG8 index score includes measures such as : (i) adjusted GDP growth, (ii) unemployment rate as percentage of total labor force aged 15 and over, (iii) employment-to-population ratio, and (iv) youth not in employment, education or training (NEET) as a share of population aged 15 to 29. SDG8 affects competitiveness as competitiveness is the ability to increase consumption and production measured as gross domestic product.

Two additional instrumental variables were used: (a) the share of industry in gross domestic product and (b) government effectiveness (World Bank, 2023). Instrumental variables are assumed to be exogenous in our models. The share of industry in gross domestic product is not part of any of the SDG index scores, but it affects both competitiveness and the climate change. The measure of government effectiveness captures the excellence in policy creation and execution, as well as the trustworthiness of the government's dedication to these policies. It is obtained from the World Bank datase (2023), which have used the Kaufmann et al.'s (2010) Worldwide Governance Indicators. The government effectiveness measure influences both competitiveness and climate related policies and their execution with a country.

Statistical analysis was done with a statistical software package STATA 17. All data were transformed into logarithmic form to account for discrepancies between the datasets. Descriptive statistics of the transformed variables are given in Table 1.

Table 1. Descriptive statistics of the variables

Variable	Mean	Std. Dev	Min	Max
ln GCI	4.6512	0.0047	4.6430	4.6602
ln SDG6	5.2117	0.0407	5.1137	5.2733
ln SDG7	5.1621	0.0417	5.0137	5.2711
ln SDG8	5.1816	0.0384	5.0257	5.2405
ln SDG12	5.1238	0.0569	4.9890	5.2236
ln SDG 13	5.0920	0.0758	4.8929	5.2357
ln SDG14	5.0878	0.0655	4.9406	5.2453
ln SDG15	5.2003	0.0542	5.0764	5.2877
ln IND	4.8122	0.0483	4.7003	4.9323
ln GE	5.1965	0.0733	4.9666	5.2983

N = 297

Source: SDG index database and the WEF's Global Competitiveness Reports (2023), authors' calculations

Table 2. Correlation coefficients between the variables

	1	2	3	4	5	6	7	8	9	10
1	1									
2	0.4229**	1								
3	0.1497**	0.4934**	1							
4	0.6599**	0.2663**	0.3121**	1						
5	-0.7002**	-0.1927†	0.2141†	-0.3542†	1					
6	-0.6743**	-0.2107**	0.2887**	-0.4023**	0.8643**	1				
7	0.1809**	0.4115**	0.2662**	0.3074**	0.0673	-0.1231*	1			
8	-0.1422*	-0.0049	0.1434*	0.2207**	0.2099**	0.0358	0.5246**	1		
9	-0.0624	0.1963**	0.2006**	0.3527**	0.3569**	0.1946**	0.3970**	0.4316**	1	
10	0.8169**	0.3706**	0.1084†	0.5400**	-0.7747**	-0.7375**	-0.0326	-0.2165**	-0.2873**	1

Note: ** p<0.01, * p<0.05, † p<0.1.

(1) ln GCI, (2) ln SDG6, (3) ln SDG7, (4) ln SDG8, (5) ln SDG12, (6) ln SDG13, (7) ln SDG14, (8) ln SDG15, (9) ln IND, (10) ln GE

Source: SDG index database and the WEF's Global Competitiveness Reports (2023), authors' calculations

Diagnostic tests were performed on the variables of interest. Table 2 depicts correlation coefficients for the variables in the model. Majority of the variables are statistically significantly correlated; hence, the test for multicollinearity is performed. The conventional approach states that the variance inflation indicator should not be either larger than 5 or larger than 10. The highest variance inflation indicator in our model is 5.69 indicating multicollinearity might pose a problem. When the variable with the highest VIF, ln SDG13, is removed from the model, variance inflation indicators of other variables fall below 2. As ln SDG13 is crucial for examination of the effect of climate change on competitiveness, this study presents two models, with and without ln SDG13.

Econometric analysis examined the relationship between competitiveness, measured with GCI score, and climate change, measured with SDGs index scores.

$$U = (GCI_{t,i}, SDG_{i,t}) \tag{1}$$

In this study the number of groups (N = 27) is larger than observed time periods (T = 11), N > T. Endogeneity in the model was tested and results indicate that endogeneity might be present in the model. Unit root tests were also performed on all variables in the model, and majority of the variables in the model become stationary when first differenced. In cases when N > T, the existence of within group cross-sectional dependence, and dependent variable with time lags in a model, a popular method of estimation is a dynamic model with a set of instrumental variables and generalised method of moments (e.g., Arellano and Bond 1991; Arellano and Bover 1995; Blundell and Bond 1998). Difference GMM is a dynamic panel data estimator that controls for endogeneity of the lagged dependent variable in a dynamic panel model, and in cases of correlation between the explanatory variables and the error term in a model, it controls for omitted variables bias and unobserved panel heterogeneity. In this paper, difference GMM is used as it builds a system of two equations, the original and the transformed one. It also uses orthogonal deviations, which minimize the data loss.

$$\ln Y_{it} = \alpha + \varphi \ln Y_{it-1} + \beta \ln X'_{it} + \gamma \ln Z'_{it} + (\eta_i + \varepsilon_i)$$
$$for\ i = 1, 2, \ldots, N\ and\ t = 1, 2, \ldots, T \tag{2}$$

where is a dependent variable of a member state i at time t, is a dependent variable of a with one lag period, is a vector of explanatory variables, is a set of control variables, while and are errors of residual differences of two orthogonal components with fixed effect and idiosyncratic shocks, respectivelly. The equation is a random walk model and is persistent. The difference GMM might be biased when T is short. Pooled OLS, fixed effects and difference GMM models were estimated to determine whether the difference GMM is an appropriate model. The results show that the difference GMM coefficient estimate is greater than fixed effects estimate indicating that the parameter estimate is not downward biased and that the difference GMM is an appropriate model. The analysis proceeds with the difference GMM. Finally, the two step difference GMM is used because of its efficiency and robustness to heteroskedasticity and autocorrelation in relation to one step difference GMM (Roodman, 2009).

6. RESULTS

This section presents the results of the analysis of the effect of climate change SDG indicators on competitiveness measured with the Global Competitiveness Index score. Four models are presented. Firstly, fixed effects and random effects panel data regressions with a dependent lagged variable are tested to inspect the effect of the climate change SDG indicators on competitiveness (Sohag, Bamanga and Alam, 2018). Hausman test with p-value less than 0.05 implied that the fixed effect model was appropriate. Table 3 presents results of panel data regression with fixed effect and dependent lagged variable.

Table 3. Dynamic panel fixed effects model results

Variables	(S.E)	
	Model 1	Model 2
ln GCI_{t-1}	0.3311** (0.0551)	0.3403** (0.0564)
ln SDG6	0.0291* (0.0128)	0.0310* (0.0131)
ln SDG7	-0.0109 † (0.0063)	-0.0058 (0.0064)
ln SDG8	0.0259** (0.0070)	0.0182** (0.0069)
ln SDG12	-0.0362 (0.0238)	-0.0501* (0.0241)
ln SDG13	0.0140** (0.0038)	
ln SDG14	0.0040 (0.0030)	0.0057 † (0.0029)
ln SDG15	0.0009 (0.0048)	0.0019 (0.0049)
Intercept	2.9708** (0.3137)	3.0611** (0.3208)
R2	0.9697	0.9680
Adjusted R2	0.9654	0.9635
S. E. regression	0.0001	0.0001
Log likelihood	1537.495	1529.992
Akaike information criterion	-11.1296	-11.0814
Number of observations	270	270
Number of groups	27	27
Time periods	10	10
Probability (F-statistic)	0.0000	0.0000
Durbin-Watson	2.2212	2.2203

Note: Standard errors in parentheses. ** $p<0.01$, * $p<0.05$, † $p<0.1$
Model 1: fixed effects model with lagged dependent variable and ln SDG13, Model 2: fixed effects model with lagged dependent variable and without ln SDG13

Source: SDG index database and the WEF's Global Competitiveness Reports (2023), authors' calculations

Table 3 displays the results of fixed effects panel regression analysis in which Model 1 comprises all independent variables and Model 2 discards ln SDG13. Model 1 shows that ln SDG6 and ln SDG13 statistically significantly and positively affect competitiveness, while ln SDG7 negatively affects competitiveness on the 10 percent significance level. Model 2 illustrates that ln SDG6 statistically significantly and positively affects competitiveness, while ln SDG12 negatively. Ln SDG14 positively affects competitiveness on a 10 percent significance level.

Secondly, difference GMM is analysed to account for possible endogeneity within the dataset. Shapiro–Wilk W test for normal data has a significance value greater than 0.05 when ln SDG13 is included, and less than 0.05 in case of no SDG13; hence, the residuals in our model are normally distributed when ln SDG13 is included in the model. Breusch–Godfrey LM test for autocorrelation shows no presence of autocorrelation. Pesaran, Friedman and Frees tests for cross-sectional dependence show that p – values are greater than 0.05, indicating that a model with ln SDG13 does not portray signs of cross-sectional dependence, while in case of no ln SDG13 Pesaran test shows cross-sectional dependence but Friedman and Frees do not. As all three, in case with ln SDG13, and two out of three, in case of no ln SDG13, tests indicate no cross-sectional dependence, it is proceed with difference GMM.

Instrumental variables of difference GMM are exogeneous to a model. They incorporate endogenous variables with time lags 2 to 4, dummy variables in the original model and supplementary variables that are not explicitly included in the model but contribute to explaining the model under analysis. In our models, supplementary variables include the share of industry in gross domestic product and government effectiveness. The Hansen (1982) test assesses the suitability of a model by examining whether certain restrictions are justified. The resulting p-values are ideally within the range of 0.1 to 0.3. The Hansen test checks the exogeneity of a subset of predictor variables in cases where factor loadings are either zero or not correlated with each other. Moreover, the p-values for the autocorrelation function according to Arellano and Bond should not be significant, meaning they should be greater than 0.05, as indicated by Roodman (2009). The results of dynamic panel GMM regression are displayed in Table 4. Model 3 portrays the results with ln SDG13 and Model 4 without ln SDG14.

All period dummy variables were used in the model at first. As the time period in our models is rather short (T = 11), and majority of period dummy variables were dropped from our model due to multicollinearity issues, there is an identification of structural breaks in the model to obtain the periods to be included in the difference GMM. Structural break test (Bai and Perron, 1998) showed there exists a structural break in the model in 2009. The result is meaningful as it presents a period when 2008 financial crises impacted the European union economies. Hence, the time period of dummy variable 2009 is included.

In both models 3 and 4 Hansen (1982) test overriding restrictions' p-value is within the range 0.1 – 0.3, indicating that our models are appropriatelly identified. Arellano- Bond test for autocorrelation in first differences, AR(1) and AR(2), is not signficant in both models stating that the idiosyncratic error terms are not serially correlated. Hence, our models are appropriatelly indefined.

Table 4. Dynamic panel GMM regression results

Variables	(S.E)	
	Model 3	Model 4
ln GCI_{t-1}	0.4054** (0.0850)	0.4315** (0.1023)
ln SDG6	-0.0065 (0.0098)	-0.0220 (0.0296)
ln SDG7	-0.0040 (0.0081)	-0.0165 (0.0187)
ln SDG8	0.0198* (0.0078)	0.0077 (0.0082)
ln SDG12	-0.0635* (0.0230)	-0.1100** (0.0328)
ln SDG13	-0.0000 (0.0089)	
ln SDG14	0.0073 † (0.0043)	0.0104 † (0.0045)
ln SDG15	-0.0015 (0.0032)	-0.0028 (0.0045)
Year dummies	YES	YES
Number of observations	162	162
Number of groups	27	27
Number of instruments	25	25
Wald test	$\chi^2(17)=21.07$	χ^2 (18)=21.13
Hansen test overriding restrictions (p-value)	0.223	0.273
Hansen test excluding group GMM (p-value)	0.249	0.250
Hansen test excluding group GMM (p-value)	0.179	0.105
AR (1) p-value	0.284	0.278
AR (2) p-value	0.701	0.691

Note: Standard errors in parentheses. ** p<0.01, * p<0.05, † p<0.1
Model 3: including ln SDG13, Model 4: without ln SDG13

Source: SDG index database and the WEF's Global Competitiveness Reports (2023), authors' calculations

In Model 3 and Model 4 ln SDG12 statisticall significantly and negativelly affects competitiveness, while ln SDG14 positively affects competitiveness at the 10 percent significance level. SDG12 refers to waste generation and SO_2 and nitrogen emissions, all resulting from increased consumption or production. A 1 percent increase in SDG12 index score results in a decrease the competitiveness score for 0.06 – 0.11 percent, all other things equal. SDG14 refers to preservation of maritime biodiversity and oceans. A 1 percent increase in SDG14 index score results with an increase in competitiveness for approximately 0.01 percent, all other things equal.

It is interesting to note that other index scores such as SDG6, SDG7, SDG13 and SDG14 do not affect global competitiveness index. This might imply that global competitiveness index does not account for issues dealing with climate change and its slow down.

7. CONCLUSION

In today's world of increasing globalization, the concept of competitiveness can be reduced to international competitiveness, which means the ability to sell products on the global market with the intention of increasing the share, i.e., at the national level, an increase in export shares and a balance of payments surplus with the potential to raise the standard of living and GDP per capita. Today's customer buys sustainable products and supports sustainable production, so companies and countries that want to perform better on the global market must take this into account, implying increased environmental awareness and social responsibility on the part of businesses. The relationship between the current competitiveness index and the existing SDG indices was investigated in this paper in order to determine how well they are represented and whether there is a need to redefine the GCI.

This study examined the effect of the environmental change on competitiveness. Competitiveness was measured with the World Economic Forum's competitiveness index score, while climate change was measured with the United Nations' Sustainable Development Index scores. SDG Index scores 6 (preservation of freshwater), 7 (the use of energy), 12 (waste generation), 13 (GHG emissions), 14 (maritime, ocean preservation) and 15 (biodiversity preservation) were of particular interest. The results have shown that the two SDG index scores have a statistically significant effect on Global Competitiveness Index Score: SDG 12 and SDG14. SDG12 negatively affects competitiveness, while SDG14 positively affects competitiveness while other SDG goals were not statistically significant (SDG 6; SDG 7; SDG 8; SDG 13; SDG 15). Given that sustainable production is always associated with higher production costs, it is understandable that the relationship is negative, especially given that price is still the most important determinant of competitiveness in the majority of European countries. It is clear that the aggregated sustainability goals have no effect on GCI, implying the need for future research to form a new unit with 5 pillars that will adequately capture the impact of the environment on competitiveness. Companies', sectors', and the national economy's competitiveness has evolved into sustainable competitiveness, which means gaining a larger market share, i.e., increasing GDP per capita without negatively impacting the environment, i.e., achieving growth without jeopardizing the basis of growth for future generations.

There are several limitations to this research. Firstly, the Global Competitiveness Index data are available for the periods 2007-2017, afterwhich the methodology of the score calculation altered. The econometric analysis was confined to the period of data availability. Secondly, the econometric analysis was based on the difference GMM because $T < 25$ and $N > 25$ to control for endogeneity. As $N = 27$, i.e., slightly greater than 25, we also used fixed effects panel data regression with lagged dependent variable. Although difference GMM is commonly used in cases of dynamic dependent variable, small T and large N, independent variables that are not strictly exogenous, fixed individual effects, among others, adding suplementary instruments could result in different estimated. Thirdly, the SDG Index scores are compilation of climate change measures, making it difficult to pinpoint a specific indicator that contributes to the change in competitiveness. Future studies should examine how specific climate change indicators, rather than their compilation, affect competitiveness over longer time period.

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ECONOMICS
Innovative and Economics Research Journal
Volume 12, No. 1, 2024
www.economicsrs.com

UNCOVERING THE INTERPLAY BETWEEN SOCIAL WELFARE PREFERENCES AND SOCIETY 5.0 ACHIEVEMENT: IMPLICATIONS FOR SUSTAINABLE DEVELOPMENT

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Received 08.01.2024. | Sent to review 18.01.2024. | Accepted 05.04.2024.

Original article

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JEL: Classification: H55, I30, P51

Doi: 10.2478/eoik-2024-0009

UDK: 364.4:351.84

ABSTRACT

The paper delves into the concept of Society 5.0, which envisions a future society integrating advanced technologies with human-centred values to address current social challenges. It emphasizes the importance of aligning advanced technologies with human-centred values and social preferences to ensure the success and sustainability of Society 5.0. We offer comprehensive insights into the complex interplay between social welfare preferences and societal progress, emphasizing the significance of understanding and addressing societal preferences to foster inclusive, sustainable, and efficient societies aligned with the objectives of Society 5.0. The findings provide valuable guidance for policymakers and stakeholders in developing targeted interventions and policies that address critical societal challenges and foster progress across various well-being dimensions. The study emphasizes the importance of considering social preferences in the development of Society 5.0 and highlights the need for a holistic approach that integrates social preferences into the development framework. The study unveils that economic success does not guarantee societal advancement, as the array of social preferences reflecting the diversity of SWP impacts a country's trajectory towards Society 5.0. By combining theoretical and empirical methodologies, we offer robust qualitative and quantitative insights for crafting optimal policies across different scenarios of individual SWPs and their effects on achieving social progress

Keywords: *society 5.0; preference; welfare; heterogeneity; social progress; development*

1. INTRODUCTION

In 2016, the Japanese government's fifth Science and Technology Basic Plan coined the concept of Society 5.0 to envision the future society towards which Japan should move (Council of Science, Technology and Innovation, 2016). This concept refers to a new development model in which the current social challenges are faced by fully utilizing information and communication technology (Deguchi et al., 2020). Society 5.0, also called "super-smart society", aspires to be a human-centred society, conceived as a sustainable and inclusive system, where the fusion of cyberspace and physical space would allow everyone to enjoy a high-quality life (Huang et al., 2022; Dluhopolskyi & Zhukovska, 2023).

Society 5.0 presents a compelling vision for a new societal model integrating advanced technologies with human-centred values. The potential benefits of this model are vast and far-reaching, and it has the power to transform human lives in incredible ways. By integrating cyberspace and physical space, reframing the relationship between technology and society, using advanced technologies to enhance various aspects of life, focusing on solving societal issues, advancing corporate social responsibility, and establishing compatible legal norms, we can create a more sustainable, inclusive, and efficient society that benefits everyone.

As countries move towards Society 5.0, it is essential to consider people's beliefs, social norms, and preferences as fundamental factors shaping their development and success. While advanced technologies are vital to this new societal model, they must align with human-centred values and aspirations. If we ignore or disregard the perspectives and preferences of individuals and communities, we risk encountering resistance, distrust, and, ultimately, the failure of initiatives to realize the vision of Society 5.0. This is why incorporating diverse viewpoints, understanding cultural nuances, and respecting societal values is essential for this new model's acceptance, adoption, and sustainability. Society 5.0 can genuinely reflect the needs and aspirations of the people it serves by prioritizing inclusivity and involving stakeholders in the design and implementation process, aiming to foster social progress on country and global levels.

At the same time, social progress is a complex and dynamic concept that extends beyond economic indicators to include cultural, historical, and individual factors. It is characterized by its dual nature, addressing both societal structures and personal development, and is influenced by the density and quality of social interactions. Recognizing the limitations of GDP as a sole measure of prosperity, there is a shift towards more comprehensive metrics that reflect the actual state of societal advancement and individual fulfilment.

The transformations required to move towards Society 5.0 imply the joint and coordinated efforts of individuals, local governments, and policymakers. We aim to analyze how the configuration of social preferences affects countries' development and score in Society 5.0 transformation. In particular, we pose the relationship between social welfare preferences (proxied by social norms and stereotypes) and Social Progress Index© (SPI), as proxy measurements of Society 5.0 achievement. In turn, SPI provides a valuable tool for policymakers to assess the extent to which progress is being made towards achieving the United Nations Sustainable Development Goals (SDGs), which can be considered one of the pillars of Society 5.0 (Zengin et al., 2021; Artyukhov et al., 2022).

In our study, we explore the relation between preferences for social welfare and the Social Progress Index (SPI) in the framework of Society 5.0, a conceptualization of a novel comprehensive well-being community. This investigation is crucial as Society 5.0 promotes the amalgamation of cutting-edge technologies with human-centred principles to establish a society that emphasizes the well-being of all its constituents. By examining the impact of social welfare preferences on the SPI, a metric assessing diverse aspects of social advancement, we can acquire insights into implementing Society 5.0 principles and their contribution to societal well-being. This analysis enables us to evaluate the concordance between societal values, as indicated by social welfare preferences, and the tangible progress made in fundamental areas such as education, healthcare, and environmental sustainability. Ultimately, scrutinizing this relationship allows us to appraise the efficacy of societal frameworks and strategies in nurturing a more inclusive and prosperous society aligned with the objectives of Society 5.0.

2. LITERATURE REVIEW

Society 5.0 is a forward-thinking idea that combines cutting-edge technologies with human-centred principles to establish a sustainable, inclusive, and effective society. This framework aligns economic advancement with resolving societal issues by harnessing digital innovation to cater to various needs, irrespective of age, location, gender, or language barriers. The potential advantages of Society 5.0 are extensive and profound, presenting the ability to revolutionize our lives in extraordinary ways. Key features of Society 5.0 include the fusion of virtual space and physical space, reimagining the interaction between technology and society, utilizing advanced technologies to enrich various facets of life, concentrating on addressing societal challenges, promoting corporate social responsibility, and implementing appropriate legal standards to tackle legal and ethical dilemmas stemming from novel technologies. These characteristics establish a framework for advancing society and shaping a more promising future.

As emphasized by Deguchi et al. (2020), the integration of virtual space and physical space is a pivotal element of Society 5.0. This merger caters to diverse requirements across different demographics, creating a more inclusive society where the advantages of technological progress are accessible to all. Revising the correlation between technology and society, as mandated by Society 5.0 (2020), is crucial to cultivating a more human-centric society. This paradigm shift allows us to perceive technology as a tool for addressing societal dilemmas and enhancing the overall well-being of individuals.

Cutting-edge technologies such as artificial intelligence, the Internet of Things, big data, cloud computing, and biometrics can elevate various aspects of life, encompassing healthcare, the environment, and ethical considerations (Althabhawi et al., 2022; Sharp, 2020). These technologies have the potential to help us construct a more effective and sustainable society that benefits all individuals.

As Rojas et al. (2021) highlighted, tackling societal issues like ageing populations, plummeting birth rates, and bolstering competitiveness through sustainable development objectives is a critical facet of Society 5.0. By addressing these problems, we can shape a society that is more attuned to the needs of its populace and better prepared to confront future challenges. As Althabhawi et al. (2022) underscored, advancing corporate social responsibility is a fundamental component of Society 5.0. Integrating technology to tackle social issues and foster responsible economic progress can aid companies in crafting a more sustainable future for all. Finally, as emphasized by Potočan et al. (2020), establishing suitable legal standards to address legal and ethical hurdles arising from new technologies is a key element of Society 5.0. Legal and ethical challenges are inherent in the adoption of new technologies, underscoring the importance of establishing fitting legal norms to ensure the responsible and ethical deployment of these technologies.

The formulation of the Society 5.0 model necessitates a sustainable development path for nations, requiring both individuals and policymakers to make unbiased decisions for the benefit of the populace. Decision-makers must therefore prioritize social welfare preferences over self-interest, focusing on what is best for society as a whole. These preferences involve the collective mechanisms and strategies aimed at promoting societal well-being, often expressed through social welfare functions that represent society's views on the distribution of welfare among its members. Such preferences emphasize principles of efficiency and equity, aiming to optimize resource allocation for the betterment of society (Treibich, 2014).

Traditional economic models typically assume that self-interest is a primary motivation for decision-makers, downplaying the influence of social motives. However, studies on bargaining, cooperation, and global surveys have challenged this assumption, revealing that self-interest alone is insufficient in explaining human behavior. This has led to a significant body of research on social preferences, which seek to incorporate altruism, aversion to inequality, and efficiency concerns into the analysis of decision-making processes. Notable models include the inequality aversion model by E. Fehr and K. Schmidt (Fehr & Schmidt, 1999), the equity-reciprocity-competition model by G. Bolton and A. Ockenfels (Bolton & Ockenfels, 2000), and the reciprocity model by G. Charness and M. Rabin (Charness & Rabin, 2002). Scholars stress the importance of comprehending individual viewpoints on the balance between equality and efficiency, a crucial aspect of contemporary democratic governance (Hong et al., 2015).

Experimental economists have explored social preferences by analysing how individuals make distribution decisions as impartial social planners (Gaertner & Schokkaert, 2012). In these studies, researchers often assume uniform preferences among individuals, estimating a single welfare function for all rather than individual social welfare functions. However, when individuals take on the role of social planners in decision-making, their personal incomes are not at risk. Studies in this area, known collectively as "social welfare preferences", examine how individuals navigate the tradeoff between equality and efficiency. Research by S. Traub et al. (Traub et al., 2009) has indicated that social planners uninvolved in the planning process tend to exhibit randomisation preferences. Other studies have shown that individuals exhibit a wide range of preferences for equality and efficiency when faced with such tradeoffs (Hong et al., 2015).

Social preferences refer to an individual's attitudes and behaviors towards others in social and economic contexts. These preferences are often characterized by inequality aversion, altruism, reciprocity, and fairness. In the context of economic decision-making, social preferences influence how individuals weigh their own outcomes against the outcomes of others and how they respond to social comparisons and interactions. Social preferences can be estimated and quantified through experimental methods, and they play a crucial role in shaping cooperation, resource allocation, and the demand for information about others' economic decisions and outcomes (Tasch et al., 2018).

As the founders of the identity economy have proved, incorporating identity and norms yields a theory of decision-making where the social context matters (Akerlof & Kranton, 2010; Okulich-Kazarin et al., 2024; Zatonatska et al., 2023). Therefore, social preferences are heterogeneous, as individuals' and countries' identities and societal conditions vary. Some researchers explore such individual preference heterogeneity when facing the tradeoff between equality and efficiency (Okun, 2015) and found different attitude groups of individuals in similar decision-making situations. Although self-interest influences individuals' decisions to a degree, some research suggests that concerns about social welfare likewise figure prominently in decisions made across various situations. For example, decision-makers' ideological dispositions, rather than self-interest, play a central role in their attitudes toward welfare assistance (Alesina et al., 2004; Funk & Garcia-Monet, 1997). On the other hand, G. Akerlof and R. Kranton (Akerlof & Kranton, 2010) proved that individual perceptions and the social context of the decision-making process substantially impact welfare attitudes.

Understanding heterogeneity in social welfare preferences requires studying individuals' preferences for subgroups in different dimensions to develop specific measurements at the country level. Social preferences play a pivotal role in shaping the vision of Society 5.0, where advanced technologies converge with human values to foster a sustainable and inclusive society. These multifaceted constructs encapsulate how individuals navigate their interests alongside societal well-being, guided by the intricate web of social norms, cultural influences, and educational experiences. Leveraging resources like the World Values Survey (WVS) enables us to dissect these preferences across diverse societies, offering invaluable insights into their evolution (Haerpfer et al., 2022).

Despite the growing literature in welfare economics and development, which stresses the role of individual social welfare preferences, the values that make up the social welfare attitude at the country level are still unknown. Moreover, attempts have yet to empirically link individual SWP with economic or social development achievement using modern multivariate data analysis methods.

According to the global nonprofit Social Progress Imperative, "Social progress is the capacity of a society to meet the human needs of its citizens, establish the building blocks that allow citizens and communities to enhance and sustain the quality of their lives, and create the conditions for all individuals to reach their full potential" (SPI, 2022). In turn, to proxy social progress, they provide the SPI "that measures how well a society provides its people with the things they care about" (SPI, 2022).

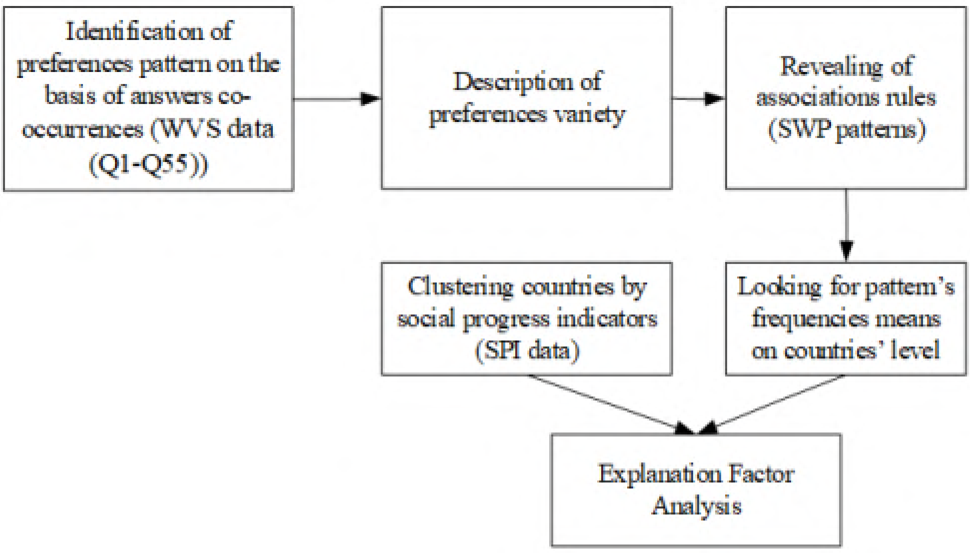
3. AIM OF THE RESEARCH

The article's main objective is to reveal relationships between SPW diversity and the achievement of Society 5.0, which is proxied by social progress. The paper strives to answer the following research question: Is it possible to determine relationships between various social welfare preferences and social development in dimension of Society 5.0? Consequently, we hypothesize that social welfare preferences are related to social progress and affect countries' prospects for Society 5.0 development.

4. METHODS

This article relies on the unique combination of statistics, multivariate explanatory techniques, and procedures for an empirical factor modelling of socioeconomic development in the context of achieving social progress. According to the authors' empirical research design (Fig. 1), our study uses the World Values Survey, Joint EVS/WVS 2017-2022 datasets, and Social Progress Indicators© data as the main empirical material.

Figure 1. Empirical research design



Source: developed by authors

The World Values Survey (WVS) is the most comprehensive survey of worldwide beliefs, attitudes, and values. It has seven waves for the period 1981-2022, which, in total, include approximately 440,000 observations, corresponding to 106 countries and representing almost 90%

of the world's population. The empirical literature uses several of the questions included in the WVS as a proxy for social preferences. It has been used to analyze the relationship of altruism with concern about global warming and fraud (Knechel & Mintchik, 2022; Kennard & Schnakenberg, 2021).

The seventh wave of WVS (Haerpfer et al., 2022) contains questions about Social Values, Norms and Stereotypes. Specifically, questions Q1-Q45 ask respondents about the importance of family, friends, leisure time, politics, and work. In addition, ask about preferences regarding the children`s qualities, neighbors, gender differences, immigration, and tolerance over diversity. Questions Q46-56 focus on Happiness and Well-being and include information about subjective perceptions of happiness, mental and physical health, freedom and social choice, life and home satisfaction, and frequency of socio-economic difficulties in the household.

We use the Social Progress Index© (SPI) to measure Society 5.0 achievement because SPI rigorously measures a country's performance on many aspects of social and environmental performance relevant to countries at all levels of economic development. It enables an assessment of not just absolute country performance, but relative performance compared to a country's economic peers (Haerpfer et al., 2022). The SPI allows access to a country's success in economic progress and improved social outcomes (Table 1).

We use cross-country panel data on 170 countries, which SPI comprehensively ranks according to the Social Progress Index framework.

Table 1. Social Progress Index Framework

Basic human needs		Foundations of wellbeing		Opportunity	
Nutrition and basic medical care	Unemployment	Access to basic knowledge	No schooling	Personal right	Political rights
	Maternal mortality rate		Primary school enrolment		Freedom of peaceful assembly
	Child mortality rate		Secondary school attainment		Freedom of religion
	Child stunting		Gender parity in secondary attainment		Access to justice
	Death from infection diseases				Property rights for woman
	Diet low in fruits and vegetables		Access to quality education		Freedom of discussion
Water and sanitation	Access to improved sanitation	Access to information & communication	Mobile telephone subscriptions	Personal freedom & choice	Vulnerable employment
	Access to improved water source		Internet users		Early marriage
	Unsafe water, sanitation, and hygiene		Access to online governance		Satisfied demand for contraception
	Sanitation and water quality		Alternative sources of information index		Corruption
					Freedom of domestic movement
					NEET youngsters

Basic human needs		Foundations of wellbeing		Opportunity	
Shelter	Access to electricity	Health and wellness	Life expectancy at 60	Inclusiveness	Acceptance of gays and lesbians
	Household air pollution		Access to essential services		Equal protection index
	Dissatisfaction with housing affordability		Access to quality healthcare		Equal access index
			Satisfaction of the availability of quality healthcare		Discrimination and violence against minorities
	Usage of clean fuels and technology for cooking		Premature death from non-communicable diseases		Power distributed by sexual orientation
					Access to public services distributed by social group
Personal safety	Interpersonal violence	Environmental Quality	Outdoor air pollution	Access to advanced education	Expected years of tertiary education
	Transportation-related injuries		Lead exposure		Women with advanced education
	Political killing and torture		Particulate matter pollution		Quality weighted universities
	Intimate partner violence		Species protection		Academic freedom
	Money stolen				Citable documents

Source: SPI, 2022

The goal of one of the techniques we use in this article is to detect relationships between sets of specific answers to WVS, which are represented by an extensive data set of categorical variables. These powerful exploratory techniques have broad applications in analyzing consumer preferences. They allow for uncovering hidden patterns in large data sets, such as "ones who said positive things about initiative *X* also frequently complain about issue *Y* but are happy with issue *Z*" (Agrawal et al., 1993). Implementing the so-called a priori algorithm (Agrawal et al., 1993; Witten & Frank, 2000), such a data analysis method allows processing huge data sets for such associations based on predefined threshold values for detection.

By employing the Association Rule Analysis technique, we find associations between the answers, i.e., derive association rules that identify the answers and co-occurrences of different survey questions' answers that appear with the greatest (co-)frequencies. We use the Association Rules module of STATISTICA software to find rules of the kind. If *X*, then (likely) *Y*, where *X* and *Y* represent single values, items, words, etc., or conjunctions. The algorithm determines association rules without specifying the number of distinct categories in the data or any prior knowledge regarding the essential associations' maximum factorial degree or complexity.

When applying algorithms for deriving association rules of the common general form: "*If* [*Body*] *is - then* [*Head*]", the support is computed as the joint probability (relative frequency of co-occurrence) of the *Body* and *Head* of each association rule. The *Confidence* value denotes the conditional probability of the *Head* of the association rule, given the *Body* of the association rule. The *correlation* value is computed as the support value for the rule, divided by the square root of the product of the support values for the body and head, which are computed separately.

Our study utilizes association rules to reveal co-occurrence patterns in datasets with varying answer frequencies. Through Association Rule Analysis, we aim to uncover and derive rules that showcase the most frequent co-occurrences among WVS responses, offering a quantitative understanding of relationships and valuable insights. Analyzing association rules allows for identifying significant global patterns in social preferences. At the same time, the algorithms help uncover hidden patterns of societal norms and values, providing insights for policy-making and social interventions to promote inclusive and tolerant communities.

We also use cluster analysis to answer researchers' general question: How can we organize observed data into meaningful structures? The *k*-means cluster analysis divides observations into groups based on similarity in clustering values. Here, *k* defines the number of pre-defined clusters that must be created. The method aims to divide *n* observations into *k* clusters so that each observation belongs to the cluster with the closest mean value. The method is based on minimizing the sum of squared distances between each observation and the center of its cluster, that is, a function:

$$\sum_{i=1}^{N} d\left(x_i, m_j, (x_i)\right)^2 \tag{1}$$

where d – is a metric; x_i – is the i-th data object; m_j – is the cluster center to which the element x_i is assigned at the j-th iteration.

It is an iterative algorithm that divides the unlabeled dataset into k different clusters so that each dataset belongs to only one group with similar properties. This allows us to cluster the data into different groups and is a convenient way to discover the categories of groups in the unlabeled dataset. The main aim of this algorithm is to minimize the sum of the distances between the data points and their corresponding clusters.

We employ discriminant analysis to explain cluster differences and determinants of groping better. The Discriminant Analysis (DA) technique, introduced by R. Fisher in 1936, is utilized to comprehensively examine group differences in a multivariate context. It proves advantageous for elucidating various aspects such as describing, summarizing, and understanding the distinctions between groups, identifying the most relevant continuous variables that define group differences, outlining the dimensional aspects of group distinctions similar to how factor analysis elucidates the dimensions of continuous variables, evaluating theories incorporating stage concepts or taxonomies, and investigating the essence of group differences post multivariate analysis of variance (MANOVA) (Borgen & Seling, 1978). DA is employed to ascertain which variables have the most discriminatory power between multiple groups, with the core objective of identifying variables that effectively distinguish between predefined groups (Bartholomew, 2010). Linear DA is proficient in determining the optimal linear regression combination, yielding a robust slope estimation in linear regression data grouped by categories (Atkinson & Cox, 1977). The primary aim of discriminant analysis is to establish a linear equation for each group that maximizes the distinctions among the weighted group means.

We also use Exploratory Factor Analysis (EFA) in our empirical research because some things cannot be observed directly and must be inferred from multiple indirect measurements. EFA provides a data-driven method to optimally combine these indirect measurements to infer the number of unobserved factors. Ideally, EFA should identify how many unobserved factors the indirect measures help estimate (factor extraction) and accurately capture how well each indirect measure assesses each factor (Megee, 1965; Krost et al., 2019). The Principal Components Analysis (PCA) is one of the EFA methods, which is a technique of decreasing many interdependent variables to a small number of correlated ones called Principal Components or factors (PC) (Jolliffe, 2002). Using Principal Component Analysis, we can replace many correlated explanatory variables (independent variables) with a limited number of new explanatory un-correlated variables called principal components. In the presented approach, not only is the dimension of the problem reduced, but a few multi-co-linearities won't occur. This article used the PCA method to reduce the number of explanatory variables and examine the relationship between social progress indicators and SPW heterogeneity.

5. RESULTS

Variations in social norms can be traced back to the diversity of social preferences. These norms, influenced by cultural, historical, and societal factors, significantly shape individuals' attitudes, values, and actions. Disparities in the perception and adherence to these norms contribute to the observed social preferences. Individuals from different backgrounds may prioritize distinct values or display varying behaviors influenced by the prevailing social norms in their communities. Understanding these nuances in social norms offers valuable insights into the heterogeneity in social preferences toward society's well-being across various populations.

The frequency analysis of WVS responses allows us to describe global variety and patterns in social values, norms, stereotypes, and happiness and well-being self-assessments as proxies of social preferences. The frequency analysis of responses to questions Q1-Q56 revealed answer variants for 24 questions (among 56 questions of the initial data set) with the highest frequencies, each having a support level exceeding 60% (Table 2). A used notation to answer variants for tables is: Very important – VI; Not mentioned – NM; Important –I; Mentioned – M.

Table 2. Frequent WVS answers

N	Survey answers	Frequency	Support (%)
1	Q1=VI	78979	90
2	Q7=I	67888	77
3	Q10 =I	57202	65
4	Q11-NM	68354	78
5	Q12-I	54862	62
6	Q13=NM	60494	69
7	Q14=NM	57994	66
8	Q15=NM	55145	63
9	Q16- NM	62995	72
10	Q17=NM	58701	67
11	Q18=M	72779	83
12	Q19=NM	72466	83
13	Q21=NM	67683	77
14	Q23-NM	71304	81
15	Q24=M	60351	69
16	Q25 =NM	63940	73
17	Q26=NM	72980	83
18	Q34_3=Agree	61300	70
19	Q42=Our society must be gradually improved	55157	63
20	Q44=Good thing	60496	69
21	Q51=Never	59536	68
22	Q52=Never	56907	65
23	Q53=Never	52802	60
24	Q55=Never	72475	83

Source: authors' computations based on EVS/WVS, 2022

As seen from Table 2, the global pattern in social norms is that family is very important for 90% of respondents worldwide (question Q1, a variant of the answer – very important). In terms of social values, norms and stereotypes related to children's qualities, we observe a global pattern manifested in the fact that good manners are considered important for children by 77% of survey respondents (Q7); a sense of responsibility is deemed an important quality in children by 65% (Q10); tolerance and respect for other people are important child quality for – 62% (Q12). At the same time, imagination is not mentioned as an important child quality that can be encouraged to learn at home (Q11) – 77% also thrift saving money and things (Q13), determination perseverance (Q14), religious faith (Q15), unselfishness (Q16), obedience (Q17) are not mentioned as important child qualities at a statistically significant level.

As for tolerance towards those around them, 83% of the respondents would not like to have drug-dependents as neighbors (Q18) and 69% – heavy drinkers (Q24). At the same time, more than 65% up to 82% of respondents accept people of a different race (Q19); immigrants/foreign workers (Q21); people of a different religion (Q23); unmarried couples living together (Q25); people who speak a different language (Q26) as neighbors. Despite the trend of tolerance towards immigrants in social norms, 70% of respondents agree that employers should prioritize national people over immigrants (Q34_3).

A significant global pattern in social preferences is that 63% believe that reforms must gradually improve one of the basic attitudes concerning our society (Q42). More emphasis on technology in the near future would be good for various changes in the way of life (Q44) for 69% of the cohort. According to respondents' answers, 68% never went without enough food to eat (Q51); 65% never felt unsafe from crime in their own home (Q52); 60% – never went without needed medicine or treatment that needed (Q53); 83% – never gone without a safe shelter over their head (Q55).

As mentioned above, association rules algorithms are a powerful tool for uncovering meaningful co-occurrence patterns in datasets with different frequencies of answers. They provide a structured and quantitative approach to understanding relationships and can offer valuable insights for decision-making and understanding complex behaviors. We have retrieved global association rules from WVS (wave 7) on two sets of WVS' core variables: 1) social values, norms, and stereotypes; 2) happiness and well-being.

The association rules exhibit substantial statistical significance, featuring a minimum support value of 60%, a minimum confidence of 60%, and a minimum correlation of 60%.

We have two types of association rules in the WVS dataset, which represent the hidden patterns of social preferences:

1. 52 rules - One in Body – One in Head (Table 3);
2. 27 rules - One in Body – Two in Head (Table 4).

Table 3. Association Rules (One–to–One)

	Frequent item sets (according to answers)	Frequency	Support (%)
1	Q1=VI, Q7=I	61848	70
2	Q1=VI, Q11=NM	62094	71
3	Q1=VI, Q13=NM	54696	62
4	Q1=VI, Q16-NM	56803	65
5	Q1=VI, Q18-M	66101	75
6	Q1=VI, Q19-NM	65158	74
7	Q1=VI, Q21-NM	60919	69
8	Q1=VI, Q23-NM	64137	73
9	Q1=VI, Q24 =M	54913	63
10	Q1=VI, Q25 =NM	56765	65
11	Q1=VI, Q26-NM	65700	75
12	Q1=VI, Q34 3=Agree	56066	64
13	Q1=VI, Q44=Good thing	55189	63
14	Q1=VI, Q51=Never	54156	62
15	Q1=VI, Q55=Never	65940	75
16	Q7=I, Q11=NM	54439	62
17	Q7=I, Q18=M	56826	65
18	Q7=I, Q19=NM	56157	64
19	Q7=I, Q23=NM	55231	63
20	Q7=I, Q26=NM	56385	64
21	Q7=I, Q55=Never	55951	64
22	Q11=NM, Q18=M	57169	65
23	Q11=NM, Q19=NM	57044	65
24	Q11=NM, Q21=NM	53164	61
25	Q11=NM, Q23=NM	55988	64
26	Q11=NM, Q26=NM	57294	65
27	Q11=NM, Q55=Never	56759	65
28	Q16=NM, Q26=NM	52869	60
29	Q18=M, Q19=NM	61138	70
30	Q18=M, Q21=NM	56446	64
31	Q18=M, Q23=NM	60362	69
32	Q18=M, Q24=M	56122	64
33	Q18=M, Q25=NM	52771	60
34	Q18=M, Q26=NM	61745	70
35	Q18=M, Q55=Never	61238	70
36	Q19=NM, Q21=NM	62737	71
37	Q19=NM, Q23=NM	65626	75
38	Q19=NM, Q25 NM	57883	66
39	Q19=NM, Q26=NM	66388	76
40	Q19=NM, Q55 Never	60610	69
41	Q21=NM, Q23=NM	61293	70
42	Q21=NM, Q25 NM	54584	62
43	Q21=NM, Q26=NM	62181	71
44	Q21=NM, Q55=Never	56397	64
45	Q23=NM, Q25=NM	58051	66
46	Q23=NM, Q26=NM	65537	75
47	Q23=NM, Q55 Never	59677	68
48	Q25=NM, Q26=NM	58657	67
49	Q25=NM, Q55=Never	53337	61
50	Q26=NM, Q55=Never	60972	69
51	Q51=Never, Q55=Never	56083	64
52	Q52=Never, Q55=Never	52862	60

Source: authors' computations based on EVS/WVS, 2022

Fifteen association rules in the table have a body Q1 answer — “family is very important,” reflecting a social preference for family and a behavior pattern oriented towards family values. Thirteen rules have body answers reflecting social preferences for child qualities that can be encouraged to learn at home (Q7, Q11, Q18).

The pattern in social preferences related to tolerance towards neighbors is represented by 22 rules (Q18, Q19, Q21, Q22, Q23, Q25, Q26) reflecting attitudes towards different categories of individuals in the vicinity and possibly stereotypes regarding the safety of living in different environments.

Let’s note that there is no association rule and, therefore, no discernible trend in behavior based on the statement that employers should prioritize national people over immigrants (Q34_3). This would have been the indicator of nontolerant biases and stereotypes. Instead, this likely indicates the presence of certain stereotypes and concerns regarding unemployment and competition in the job market.

Table 4. Association Rules (One-to-Two)

N	Frequent item sets (according to answers)	Frequency	Support (%)
1	Q1=VI, Q18=M, Q19=NM	55482	63
2	Q1=VI, Q18=M, Q23=NM	54741	62
3	Q1=VI, Q18=M, Q26=NM	56096	64
4	Q1=VI, Q18=M, Q55=Never	56062	64
5	Q1=VI, Q19=NM, Q21=NM	56440	64
6	Q1=VI, Q19=NM, Q23=NM	59027	67
7	Q1=VI, Q19=NM, Q26=NM	59746	68
8	Q1=VI, Q19=NM, Q55=Never	55065	63
9	Q1=VI, Q21=NM, Q23=NM	55148	63
10	Q1=VI, Q21=NM, Q26=NM	56012	64
11	Q1=VI, Q23=NM, Q26=NM	59004	67
12	Q1=VI, Q23=NM, Q55=Never	54194	62
13	Q1=VI, Q26=NM, Q55=Never	55495	63
14	Q18=M, Q19=NM, Q23=NM	55565	63
15	Q18=M, Q19=NM, Q26=NM	56210	64
16	Q18=M, Q23=NM, Q26=NM	55600	63
17	Q19=NM, Q21=NM, Q23=NM	58191	66
18	Q19=NM, Q21=NM, Q26=NM	58707	67
19	Q19=NM, Q21=NM, Q55=Never	52726	60
20	Q19=NM, Q23=NM, Q25=NM	54273	62
21	Q19=NM, Q23=NM, Q26=NM	61435	70
22	Q19=NM, Q23=NM, Q55=Never	55348	63
23	Q19=NM, Q25=NM, Q26=NM	54450	62
24	Q19=NM, Q26=NM, Q55=Never	55954	64
25	Q21=NM, Q23=NM, Q26=NM	57606	66
26	Q23=NM, Q25=NM, Q26=NM	54484	62
27	Q23=NM, Q26=NM, Q55=Never	55197	63

Source: authors’ computations based on EVS/WVS, 2022

In Table 4 are thirteen association rules which have in the body Q1 answer – “family is very important”, no rules reflecting social preferences towards child qualities that can be encouraged to learn at home and fourteen rules reflecting attitudes towards different categories of individuals in the vicinity and possibly stereotypes regarding the safety of living in different environments.

Association rules based on the belief in the importance of family indicate a pattern in social preferences. Assigning high importance to the family predicts specific beliefs regarding the necessary qualities for children that should be taught in the family. Additionally, there is a notable trend in social norms and stereotypes concerning a secure living environment and tolerance towards diversity.

As the answer "Very important" to question Q1 – "Family is essential" has the highest frequency of 78979 (87676 cases total) and a support value of 90, we looked for the frequency of occurrence of the associative rules from Table 4 in the data set at each country level and obtained an indicator of the degree of heterogeneity of social preferences. SPW attitude we calculated as the mean of association rules frequencies at the countries' EVS/WVS 2017-2022 dataset for each country data level.

By k-means cluster analysis on SPI and its components (Table 5), we grouped countries into three clusters to obtain the homogenous groups of countries in the social progress dimension.

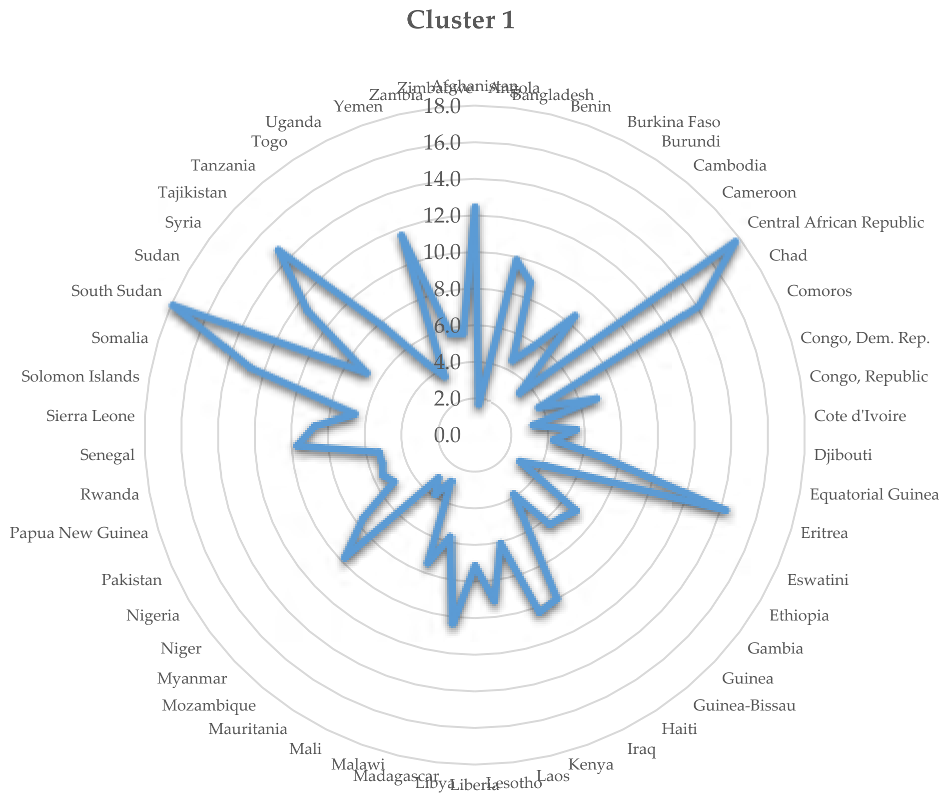
The cluster structures of countries obtained based on their level of social progress, presented in Fig. 2, indicate the differences in levels of social progress within the identified groups (three different clusters). However, simultaneously, we observe that including countries with similar levels of social progress in clusters does not confirm the statement that they are close regarding economic development.

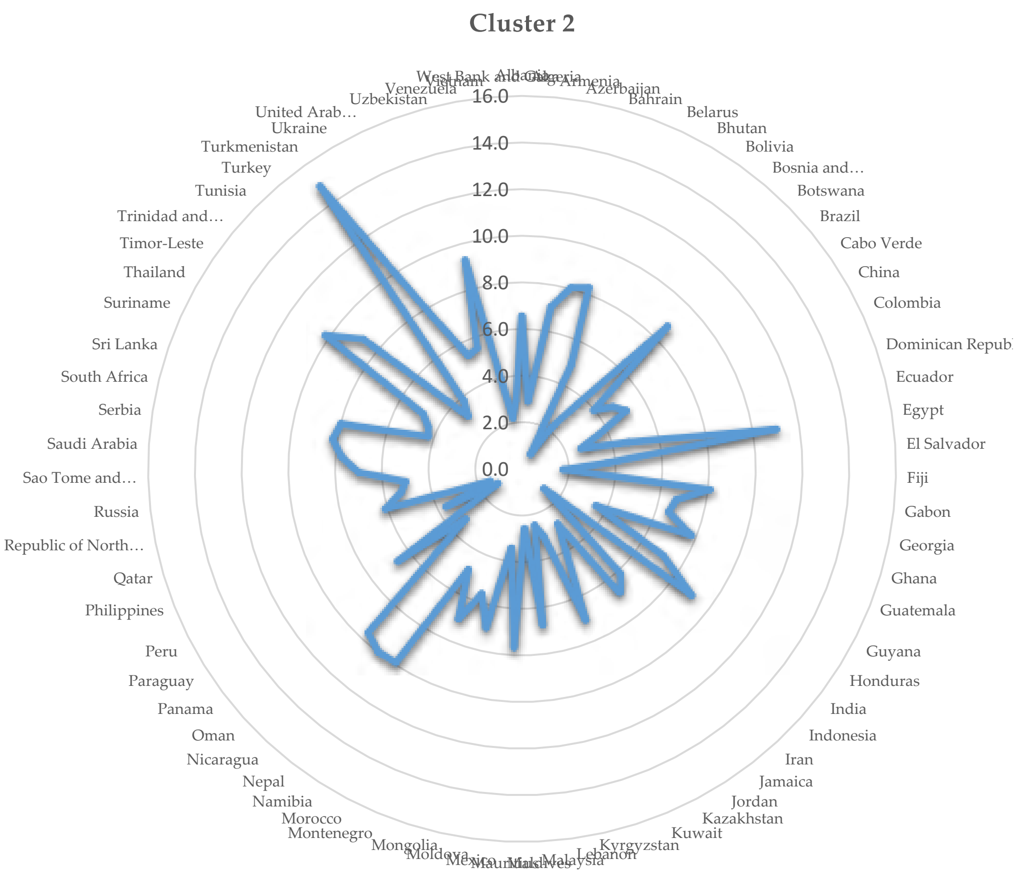
Table 5. Clusters' means for classification variables

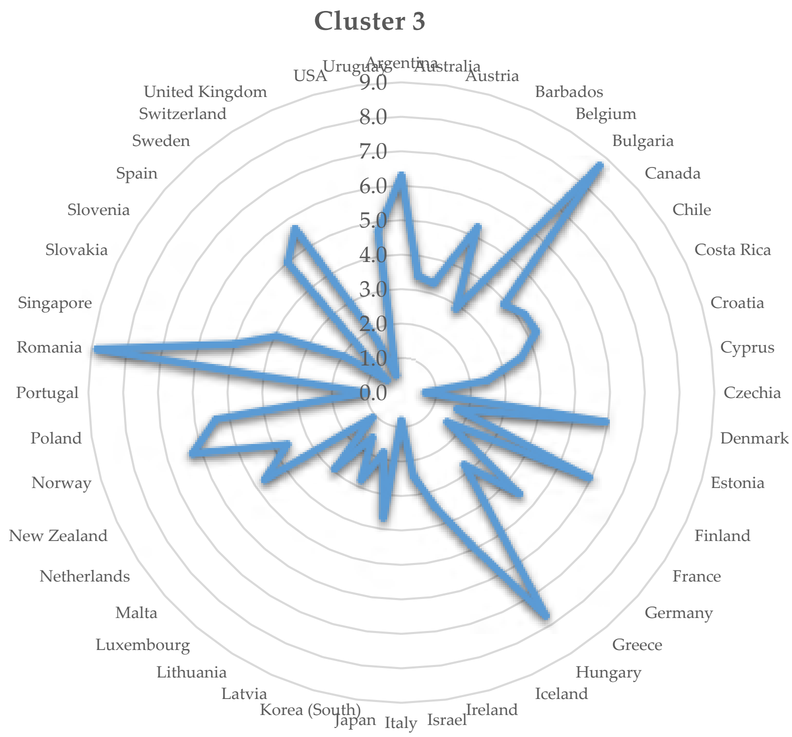
Variable	Cluster means		
	Cluster 1	Cluster 2	Cluster 3
Social Progress Index	48,52	67,84	84,85
Basic Human Needs	55,92	79,94	88,62
Foundations of Wellbeing	48,13	67,14	84,39
Opportunity	41,50	56,46	81,56

Source: authors' calculations utilizing STATISTICA 12

Figure 2. Clusters' structures: members and distance to cluster centroid







Source: authors' calculations utilising STATISTICA 12

We performed factor analysis using the Principal Components Varimax Normalized method to explain the k-means classification results based on SPW attitude and set of components (75 variables) of SPI. As a result, we obtained two important principal factors that explain 53,6% of the total variation of the analyzed dataset (Table 6).

Table 6. Factor identification and engine values

Value	Clusterised by SPI			
	Eigenvalue	**% total variance**	**Cumulative Eigenvalue**	**Cumulative %**
1	33,31	45,63	33,31	45,63
2	5,84	8,00	39,15	53,62

Source: authors' calculations using STATISTICA 12

Factor analysis confirms our hypothesis that country clustering can be explained by a latent factor structure indicating the connection between social preferences' heterogeneity and indicators of social progress. Table 7 represents this factor structure interpreted as a linear combination of significant variables from the analyzed dataset, which can explain the countries' classification in the social progress dimension.

Table 7. Principal Components, significant factor loadings (Varimax normalized)

Variable	*Variable Notation*	*Factor 1 (PC_1)*	*Factor 2 (PC_2)*
SWP attitude	X1		0,61
Nutrition & Basic Medical Care	X2	0,82	
Shelter	X3	0,85	
Water & Sanitation	X4	0,79	
Access to Basic Knowledge	X5	0,73	
Personal Rights	X6		0,81
Personal Freedom & Choice	X7		0,61
Access to Advanced Education	X8		0,42
Infectious diseases	X9	-0,77	
Maternal mortality rate	X10	-0,77	
Child mortality rate	X11	-0,82	
Unsafe water, sanitation and hygiene	X12	-0,80	
Access to improved sanitation	X13	0,79	
Access to improved water source	X14	0,71	
Household air pollution	X15	-0,84	
Academic freedom	X16		0,77
Vulnerable employment	X17	-0,70	
Political rights	X18		0,72
Freedom of discussion	X19		0,79
Freedom of peaceful assembly	X20		0,75
Internet users	X21	0,73	
Alternative sources of information index	X22		0,80
Gender parity in secondary attainment	X23	-0,74	
Secondary school attainment	X24	0,72	
Population with no schooling	X25	-0,77	
Political killings and torture	X26		0,74
Usage of clean fuels and technology for cooking	X27	0,77	
Access to electricity	X28	0,83	

Source: authors' calculations using STATISTICA 12

From the original dataset of SPI components, only 27 variables (based on the criterion of factor loadings' significance) and the indicator of heterogeneity of social preferences were included in the model. The obtained principal component factor model (PC1-PC2) reflects the interconnections among components of social progress and the heterogeneity of social preferences in the context of their influence on the sustainable development of countries:

$$PC_1 = 0{,}82X2 + 0{,}85X3 + 07{,}9X4 + 0{,}73X5 - 0{,}77X9 - 0{,}77X10 - 0{,}82X11 - 0{,}8X12 + \\ + 0{,}79X13 + 0{,}71X14 - 0{,}84X15 - 0{,}7X17 - 0{,}73X21 - 0{,}74X23 + \\ + 0{,}72X24 - 0{,}77X25 + 0{,}77X27 \quad (2)$$

$$PC_2 = 0{,}61X1 + 0{,}81X6 + 0{,}61X7 + 0{,}42X8 + 0{,}77X16 + 0{,}72X18 + 0{,}79X19 + \\ + 0{,}75X20 + 0{,}8X22 + 0{,}74X26 \quad (3)$$

The factor analysis results using the principal component method provide insights into the underlying structure of the variables related to social welfare and societal attitudes. Factor 1 (PC_1) appears to capture dimensions related to health risks, environmental challenges, socio-economic vulnerabilities, and gender disparities in education. Variables such as infectious diseases, maternal and child mortality rates, unsafe water, sanitation, hygiene, household air pollution, vulnerable employment, gender parity in secondary attainment, secondary school attainment, and population with no schooling exhibit high loadings on this factor.

Factor 2 (PC_2), on the other hand, represents dimensions associated with social welfare preferences, societal progress, individual freedoms, and access to resources. These variables collectively reflect societal well-being, individual liberties, educational opportunities, access to information, and technological advancement. These variables highlight challenges in public health, environmental sustainability, socio-economic equality, and educational attainment. These factors (1) and (2) can be used to understand the underlying structure of social welfare and development indicators and inform policy interventions to address specific needs and challenges within societies towards Society 5.0.

As a next step, discriminant analysis (DA) was conducted to identify the relationships between countries' SWPs and the social progress indicators listed in Table 1 at the highest level of aggregation of three pillars of social progress. Cluster number was chosen as the classification variable (*G*). We aim to determine whether countries are placed in a certain group depending on their social progress level and SWP attitude. This can be explained by a linear combination of variables describing social preferences and progress in achieving social progress. Table 8 shows the discriminant functions for each group of countries. These discriminant functions have good validity.

Table 8. Discriminant functions for each cluster of countries

Variable	Classification Functions; grouping: CLUSTER		
	G 1:1 p=0,4	G 2:2 p=0,56	G 3:3 p=0,45
SWP attitude	1,040	0,887	1,08
Basic Human Needs	1,037	1,501	1,61
Foundations of Wellbeing	0,268	0,370	0,51
Opportunity	0,506	0,700	1,03
Constant	-49,347	-95,238	-139,81

Source: authors' calculations using STATISTICA 12

The structure of these discriminant functions shows that variables have different discriminant weights for various countries, indicating the uniqueness of the interaction of discrimination factors across country groups. This result confirms the hypothesis that the level of social progress depends on the complex influence of factors and that there is a relationship between them and social welfare preferences as aggregate measurements of citizens' behavior patterns (derived by association rules).

The discriminant function analysis summary (Table 9) provides insights into the relationship between the predictor variables (SWP attitude, Basic Human Needs, Foundations of Wellbeing, and Opportunity) and the grouping variable (CLUSTER with three groups). The Wilks' Lambda statistic measures the model's discriminatory power, with lower values indicating better discrimination between groups. In this analysis, the Wilks' Lambda value is 0,08645, suggesting that the model effectively discriminates between the groups. The F statistic tests the overall significance of the discriminant function, with higher values indicating stronger evidence against the null hypothesis of no difference between groups. The F statistic is significant (F(8,326) = 97,846, p < 0,000), indicating that at least one of the predictor variables significantly contributes to the differentiation between groups.

Table 9. Discriminant Function Analysis Summary

	No. of vars in the model: 4; Grouping: CLUSTER (3 groups) Wilks' Lambda: 0,08645 approx. F (8,326) = 97,846 p<0,0000					
	Wilks' Lambda	Partial Lambda	F-remove (2,163)	p-value	Toler.	1-Toler. (R-Sqr.)
SWP attitude	0,1874	0,9895	0,862	0,0001	0,9646	0,3538
Basic Human Needs	0,1277	0,6767	38,935	0,0000	0,6594	0,3406
Foundations of Wellbeing	0,0884	0,9775	1,877	0,1564	0,4693	0,5307
Opportunity	0,1140	0,7586	25,941	0,0000	0,6208	0,3792

Source: authors' calculations using STATISTICA 12

Looking at the individual predictor variables we can assume:

- SWP attitude has a Wilks' Lambda value of 0,1874, indicating a strong contribution to group discrimination. The F statistic for removing SWP attitude from the model is 0.862, with a p-value of 0.0001, indicating its significant contribution.
- Basic Human Needs also significantly contribute to group discrimination, with a Wilks' Lambda value of 0,1277 and an F statistic of 38,935 for its removal from the model (p < 0.0000).
- Foundations of Wellbeing, while having a relatively higher Wilks' Lambda value of 0.0884, does not significantly contribute to group discrimination, as evidenced by its non-significant F statistic of 1,877 (p = 0,1564).
- Opportunity demonstrates a significant contribution to group discrimination, with a Wilks' Lambda value of 0.1140 and an F statistic of 25,941 for its removal from the model (p < 0,0000).

Overall, SWP attitude, Basic Human Needs, and Opportunity are significant predictors of discrimination among the country groups, while Foundations of Wellbeing does not significantly contribute to differentiation among clusters.

6. DISCUSSION

Examining association rules is crucial to uncovering distinct patterns in social preferences across various dimensions. The analysis findings are significant as they highlight the importance of family values and societal norms in prioritizing familial relationships. It is vital to instill specific values and traits in children early on, reflecting a shared ambition to develop particular attributes in future generations, mirroring broader societal aspirations and values.

Moreover, the analysis sheds light on patterns in social preferences concerning tolerance towards neighbors. Acknowledging and respecting diverse attitudes towards different groups of individuals in our vicinity is essential. While tolerance towards certain groups is observable, concerns regarding safety and perceptions of living environments may impact these attitudes and behaviors. Notably, the lack of association rules emphasizing the prioritization of native residents over immigrants indicates a need for identifiable trends in biased conduct. Instead, this may point to concerns related to unemployment and competition in the labor market, underscoring the intricate interplay of economic elements and societal outlooks.

Therefore, it is crucial to carefully understand and analyze these patterns to build a more equitable and inclusive society as Society 5.0. To create a harmonious community, policymakers must prioritize family values, instill positive attributes in children, and foster tolerance towards neighbors. The association rule analysis provides valuable insights into prevailing social preferences and behavior patterns, offering a nuanced understanding of societal norms and values. These findings affect policy-making and social interventions to foster inclusive and tolerant communities.

At the same time, the grouping of countries by the level of social progress and its main components shows that the economic development of countries only sometimes contributes to a high level of social progress and vice versa. In particular, in clusters of countries with approximately the same level of clustering indicators (social progress), the countries differ in economic development. This fact can be explained by a latent factor structure that reflects the interconnections between various social progress factors and different types of social preferences (heterogeneity of these preferences).

On the other hand, while the Social Progress Index (SPI) provides a holistic measure encompassing Basic Human Needs, Foundations of Wellbeing, and Opportunity, it's essential to recognize that high scores in these areas don't necessarily equate to equal levels of economic development across countries. The SPI considers many factors beyond economic indicators, such as access to education, healthcare, personal rights, and environmental quality. Therefore, a country may excel in providing for its citizens' basic needs and fostering social well-being while facing economic challenges or disparities in wealth distribution. Economic development is just one aspect of overall societal progress, and the SPI offers a more comprehensive view of a nation's advancement in social dimensions in context of Society 5.0.

The Principal Components analysis revealed two significant factors with distinct variable loadings. The first principal factor (PC_1), characterized by high loadings for social welfare attitudes and basic needs variables, reflects a dimension encompassing social welfare and fundamental well-being. PC_1 could be interpreted as governments' and societies' abilities to ensure basic human needs, foundations of well-being and technological access (e.g., Internet access). This factor includes variables such as personal rights, shelter, access to basic knowledge, and nutrition & basic medical care, indicating a focus on essential elements for societal welfare. Conversely, the second principal component reflects a dimension associated with societal development and political rights, as evidenced by variables like political rights, freedom of discussion, and internet users, which exhibit high loadings on this factor. Additionally, variables related to education, access to electricity, and alternative sources of information index also contribute significantly to PC_2. These findings provide insights into the underlying structures of social welfare attitudes and development indicators, shedding light on the multifaceted nature of societal well-being and progress. The second principal factor that affects countries' social progress classification we interpret as governments' and societies' abilities to assure personal freedom and opportunities for personal development.

The findings from the factor analysis provide invaluable insights into the underlying structure of variables concerning social welfare and societal attitudes. By understanding the complex dynamics between social welfare preferences and societal progress, we can advance towards a more inclusive and sustainable society. The multifaceted nature of societal challenges demands that we address them comprehensively to achieve the Society 5.0 paradigm. Moreover, the discriminant analysis offers a deeper understanding of the intricate relationships between countries' social welfare preferences and progress indicators. It reveals that SWP attitude, Basic Human Needs, and Opportunity are critical predictors for discriminating between different country groups. These factors are pivotal in shaping societal progress and informing policy interventions that address specific societal needs and challenges. Policymakers can leverage these insights to develop targeted interventions and policies that address critical societal challenges and foster progress across various well-being dimensions. The findings underscore the need for a holistic approach to societal development that considers social welfare preferences and progress indicators to effectively address the diverse needs and challenges within societies.

7. CONCLUSIONS

The findings drawn from social norms and values analysis suggest a diverse global landscape of preferences and attitudes across various societal dimensions. While certain aspects align with the principles associated with Society 5.0, such as emphasizing family values, tolerance towards diversity, and optimism about technological advancements, it is premature to conclude that a clear and uniform trajectory towards Society 5.0 exists globally. Most respondents reported consistent access to necessities like food, safety, medicine, and shelter, highlighting fundamental social welfare and well-being. In the context of Society 5.0, which envisions a human-centric society enabled by technological innovation, ensuring universal access to these basic needs is still foundational.

Society 5.0 aims to leverage advanced technologies to enhance human well-being, foster inclusivity, and address societal challenges. Therefore, these essential requirements align with the core principles of Society 5.0 by prioritizing the welfare and prosperity of all individuals. Our research's theoretical contribution is the enhanced comprehension of the interplay between variations in social welfare attitudes, social progress, and economic development outcomes. The key features of Society 5.0 revolve around leveraging advanced technologies to create a super-smart, sustainable, and inclusive society that addresses economic and social challenges. This model integrates digital and physical realms to enhance the quality of life for all individuals. Society 5.0 emphasizes the well-being and prosperity of all individuals, prioritizing inclusivity and addressing societal challenges. It aims to align advanced technologies with human-centred values and aspirations to foster a society that reflects the needs and aspirations of the people it serves. Concerning social welfare preferences, the implications of Society 5.0 are significant.

The interplay between social welfare preferences and societal progress is crucial for implementing and sustaining Society 5.0. Furthermore, the findings suggest that while advanced technologies are vital to the Society 5.0 model, they must align with human-centred values and aspirations. We emphasize the importance of recognizing the limitations of traditional economic indicators and the shift towards more comprehensive metrics that reflect the current state of societal advancement and individual fulfilment. For policymakers it's necessary to leverage insights into social welfare preferences to develop targeted interventions and policies that address critical societal challenges and foster progress across various well-being dimensions. Future practical applications of our findings encompass comparative studies to assess the commonalities in factors influencing countries' socioeconomic development, the creation of social progress matrices for nations, regions, and cities to pinpoint variations in social welfare-oriented behavior, and the integration of additional political, social, and psychological variables into studies of economic growth.

8. ACKNOWLEDGEMENTS

This project has received funding through the MSCA4Ukraine project (Ref. 1.4-UKR-1232972-MSCA4Ukraine), funded by the European Union. Views and opinions expressed are, however, those of the authors only and do not necessarily reflect those of the European Union. Neither the European Union nor the MSCA4Ukraine Consortium nor any individual member institutions of the MSCA4Ukraine Consortium can be held responsible for them.

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ECONOMICS
Innovative and Economics Research Journal
Volume 12, No. 1, 2024
www.economicsrs.com

REVEALING THE LINK BETWEEN OPEN MINDED, UNCERTAINTY READINESS AND OPTIMISM IN BUSINESS PERFORMANCE FOR FOOD AND BEVERAGE BUSINESSES

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Received 05.01.2024. | Sent to review 15.01.2024. | Accepted 05.04.2024.

Original article

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JEL Classification: L26; D81; D83; C39

Doi: 10.2478/eoik-2024-0008

UDK: 338.488.2:640.43

ABSTRACT

Business performance is an urgent topic to explore because there are many aspects that influence it. One thing that can guarantee business performance is open-minded entrepreneurship, uncertain readiness, and entrepreneurial optimism. In this context, businesses in the form of Food and Beverage (F&B) have become popular in the last few decades in Indonesia. From this research, it investigates the effects of open-minded entrepreneurs, uncertain readiness, and entrepreneurial optimism on business performance. Apart from that, it also dissects the relevance of open-minded entrepreneurship and uncertain readiness on business performance which is mediated by entrepreneurial optimism. The quantitative method was operated via an online survey involving cafe and restaurant owners (N = 128) spread across several big cities in Indonesia. Then, the data was analyzed using Structural Equation Modeling-Partial Least Square (SEM-PLS). As a result, of the five hypotheses developed, three were accepted. Open-minded entrepreneurship, uncertain readiness, and entrepreneurial optimism are proven to influence business performance. On the one hand, the other two hypotheses are rejected, where open-minded entrepreneurship or uncertain readiness have no impact on business performance through entrepreneurial optimism. By implication, the output of the research is interesting to highlight in the future. Optimism in too high a capacity can harm the business. This is triggered by the level of vigilance and actions of business owners in making decisions based on irrational emotions.

Keywords: *Open-minded entrepreneur, Uncertainty readiness, Entrepreneur optimism, Business Performance, SEM-PLS*

1. INTRODUCTION

Business studies that are always interesting to look at are about business performance, including in the context of the food and beverage industry. Then, why is that? In reality, the food and beverage business is one of the sectors that continues to grow, such as the developing market in Indonesia (Abbas & Hidayat, 2021). Amaliyah & David (2021) and Zahra (2021) note that currently there are 3.9 million food and beverage SMEs developing in Indonesia. With its fast growing units, the food and beverage industry has bright prospects and is at the same time vulnerable to government regulations and market transitions. Therefore, the urgency in understanding the structures that shape business performance in this industry is enthusiastic enough to be discussed.

Various factors can influence the increase in food and beverage business performance or vice versa. The most basic of course is the marketing mix chosen, product type, distribution channels, price attributes, and communication strategies that are appropriate to the target market (Bakator et al., 2019; Ben Uche et al., 2022; De Toni et al., 2017; Kibe, 2014; Sudarman & Lailla, 2023). However, beyond all that, there are still many dimensions that contribute to business performance. Take for example the transformation of the business environment and government regulations, the ability to observe changes, and the owner's attitude in running his business.

During the COVID-19 pandemic that hit Indonesia in early 2020, many food and beverage businesses were forced to close because they could not survive. Yet, there are also those that are actually developing rapidly with solid business performance (Rahmawati et al., 2023). In principle, businesses that can survive have extraordinary performance, including during or after a pandemic. According to Bansal & DesJardine (2014), Bocken & Geradts (2020), Ferlito & Faraci (2022), Geissdoerfer et al. (2018), He & Ortiz (2021), Najib et al. (2021), Nosratabadi et al. (2019), and Šebestová & Nowáková (2013), a sustainable business is a business that is able to adapt to dynamics, encourage innovation to produce creations, and has programs according to the designs prepared.

Businesses on an SME scale depend on the characteristics of the owner (Chakabva & Tengeh, 2023). When a business owner has a positive attitude, it will be easy to give a positive color to the business and its team, and vice versa (Sobaih et al., 2022). One of the positive actions that an entrepreneur must have is optimism (Ben Fatma et al., 2024; Hmieleski & Baron, 2009). Optimism will produce an open outlook and mind in an entrepreneur. Vamvaka et al. (2020) stated that these good thoughts and attitudes will move entrepreneurs to see opportunities and convenience in difficult critical conditions, so that businesses are more resistant to pressure.

The above practices are certainly needed by food and beverage entrepreneurs, where competition in this business is also tight with demands for speed in capturing consumer preference positions to be able to bring business success. An optimistic attitude in entrepreneurs will be more competent if combined with an open mind (Ma et al., 2024). Apart from being optimistic in planning and opening a business, entrepreneurs are required to continue learning and listening to constructive ideas, listening and receiving information from other people. On the other hand, if entrepreneurs do not focus on being open minded, it can hinder their mastery of information and technology.

The business world is seen as a dynamic environment, where there is a lot of turmoil at any time. This turmoil can originate from consumers, suppliers, the government as a regulator, and various other things. For this reason, business organizations are expected to be more responsive in facing challenges through uncertainty readiness capabilities. By implementing uncertainty readiness, a business organization can concentrate on innovation (Faulks et al., 2021; Jalonen, 2012). The scenario of this research is set to prove that optimism, open mindedness, and uncertainty readiness capabilities have a significant relationship to business performance. All of the components above are soft skills that entrepreneurs, especially organizations, should have in boosting their business. The contributions of this research center on academic and practical sustainability. The first is to examine the relationship between open-minded entrepreneurs, uncertain readiness, and entrepreneurial optimism on business performance. By delving into existing literature, insight into marketing science can be enriched through new research that discusses the factors driving business performance at the food and beverage SME scale from the aspect of managing human resources. Second, it provides visibility for food and beverage SMEs as a signal in evaluating business performance, especially internal obstacles. Technically, business performance does not only depend on the size or method used, but must also work collectively with the awareness of business actors in starting and maintaining business performance.

2. LITERATURE REVIEW

2. 1. BUSINESS PERFORMANCE

Taouab & Issor (2019) define business performance as a parameter for a company to achieve its goals and objectives. This includes measures of financial and non-financial success as well as the capability to adapt and survive in a business environment that requires many considerations (Franco-Santos et al., 2007). Business performance is key in assessing the success of a business (Yıldız & Karakaş, 2012).

From some past literature, Muharam & Atyanta (2021) define business performance as the ability of a company to realize its goals within a certain period of time, both financially and non-financially. Meanwhile, business performance is the output of designed targets (Slávik et al., 2022). On the other hand, Neely (2004) states that business performance is centered on the extent to which an organization can achieve monetary or non-monetary independence, for example operational efficiency, loyalty, customer satisfaction and brand image. In essence, business performance can be detected based on financial and non-financial spaces (Junaidi et al., 2012; Škrinjar et al., 2008). The classifications in the financial sphere are return on assets (ROA), return on investment (ROI), profits, turnover, and so on. Then, the non-financial scope includes: market share, new customer growth, company reputation, brand equity, etc. The benefit of calculating business performance is to follow up on its growth status and evaluate the policies made (Venkatraman & Ramanujam, 1986). Apart from markets and finance, business performance measurement also evaluates the manager's ability to achieve the set goals and targets. By including HR factors, it will be easier to improve business performance, track progress, and allocate business decisions.

2. 2. OPEN MINDED

In the contemporary business world, an entrepreneur must have knowledge from various points of view. Open thinking is also known as "critical insight" as an art of thinking that involves acceptance of various opinions, facts and concepts (Jung & Lee, 2022). An open-minded entrepreneur will be more easily interested and want to continue to understand all segments, because it will determine future experiences (Boldureanu et al., 2020; Jiatong et al., 2021; Kooskora, 2021; Rosado-Cubero et al., 2022). These capabilities are important for an entrepreneur to compete and succeed in his business. Thus, they can exist, discover new opportunities, and adapting business strategies to calibrate changes in the market and business environment. An entrepreneur can be more creative, consistent and rational in managing his business if he thinks openly.

Talking about open thinking, an entrepreneur has many advantages from it (Peljko & Antoncič, 2022). The ability to survive uncertain situations is one of them (Shahzad et al., 2021). Entrepreneurs who are open-minded are also more resilient and do not give up easily, which allows them to recover after failure (Liu et al., 2022). At least, entrepreneurs will be better prepared to accept criticism or new recommendations that can help expand the business. Additionally, an entrepreneur can build a successful business by thinking openly. They can more easily understand what potential business partners want, so they can build profitable relationships. In addition, an entrepreneur has a greater opportunity to collaborate because an open attitude allows them to build significant relationships with various parties, including companies in other fields.

Moreover, by having an open mind, entrepreneurs will be able to maintain or increase their business performance. Caliendo et al. (2023), Li et al. (2021), Srimulyani et al. (2023), Stephan et al. (2023), and Teruel-Sánchez et al. (2021) concluded that entrepreneurs who think openly have the opportunity to advance their business performance by recognizing business opportunities and elaborating on shifts in the business environment. Besides that, Alteren & Tudoran (2019), Cegarra-Navarro et al. (2019), Dukeov (2020), and Michna & Kmieciak (2020) explained that open-mindedness in entrepreneurs can have implications for successful business performance through expansion and networking in entering new markets.

2. 3. UNCERTAINTY READINESS

Business always faces uncertainty, especially in the modern era which is full of obstacles. There are many sources of uncertainty, such as market shifts, increased competition, and technological advances. Thus, readiness to face uncertainty functions to achieve business success.

Uncertainty readiness is an entrepreneur's ability to face problems in a proactive manner (Hidayati & Satmaka, 2018; Kromidha & Bachtiar, 2024; Peng & Walid, 2022; Setiawan, 2023; Silva et al., 2023; Simpson & Sariol, 2022). Brändle et al. (2023) and Makings & Barnard (2019) emphasize that entrepreneurs who address uncertainty comprehensively will find it easier to position themselves with new breakthroughs and make the right decisions.

Theoretically, the foundations that can influence entrepreneurs' readiness to handle uncertainty include: the ability to understand the market, adapt, take risks, and learning techniques (Martins et al., 2023). First, the ability to understand the market and business environment well can make it easier to anticipate and control business strategies according to the latest developments. Second, entrepreneurs who can adapt quickly and flexibly will be better off. Third, by taking risks, entrepreneurs can move beyond uncertainty and pursue new opportunities. Fourth, learning techniques. Through a mindset of continuing to learn, entrepreneurs can develop themselves in various conditions.

In a business context, the best steps to deal with uncertainty are essential to ensure continuous business performance, business continuity and productivity (Al-Qadasi et al., 2023). Businesses that are mature in facing uncertainty will find it easier to adopt all market trends. Entrepreneurs are required to continue to manage their business capabilities.

2. 4. OPTIMISM

Ideally, the business world relies heavily on optimism. Lim & Morris (2023) represent optimism as a tendency to believe that good events will occur, so that individuals channel a positive perspective on their lives. Later, Carver et al. (2010), Conversano et al. (2010), and Dursun (2021) argue that optimism involves an individual's belief in achieving prosperity and being able to overcome crises that arise during routine activities. In the lens towards happiness, Wijayanti et al. (2023) describe optimism as the tendency to hope that actions taken will lead to positive outcomes, and that individuals have the ability to influence those outcomes.

In the resilience model, optimism reflects the instinct of seeing challenges as an outlet for growth, not as a threat, and having confidence that internal resources can be applied to overcome adversity. Aspinwall et al. (2021) and Jefferson et al. (2017) interpret optimism as a technique for questioning beliefs and limitations that trigger an individual's view of positive possibilities. From some of the premises above, optimism is actualized not only as a positive attitude, but also involves belief in the individual's ability to escape problems and move towards the desired results (Bortolotti, 2018; Roy, 2014).

Optimistic entrepreneurs tend to be full of enthusiasm when facing dilemmas in business continuity. An entrepreneur's business is greatly influenced by perspective, especially optimism. Several reasons why optimism is an important corridor for strengthening business performance:

(1) Overcoming challenges with optimism. Problems always exist in the business world. An optimistic entrepreneur can view challenges as opportunities to grow and learn, not as obstacles to hinder the desire to progress. Entrepreneurs get inspired to work together in teams to achieve the end goal which helps them stay focused on the solution rather than getting sucked into the problem; (2) Solve failure with optimism. Not all steps in the business world can run smoothly. An optimistic entrepreneur sees failure as a way to do better dedication, not as the end of the journey. They will also more easily connect with change and even view failure as an opportunity to grow the business; (3) Build successful partnerships. Optimism also plays a vital role in establishing partnerships. They remain strong and enthusiastic in facing obstacles and do not give up easily; and (4) Bring self-confidence closer to optimism. With a high level of trust, entrepreneurs can motivate and inspire other people to build greater relationships.

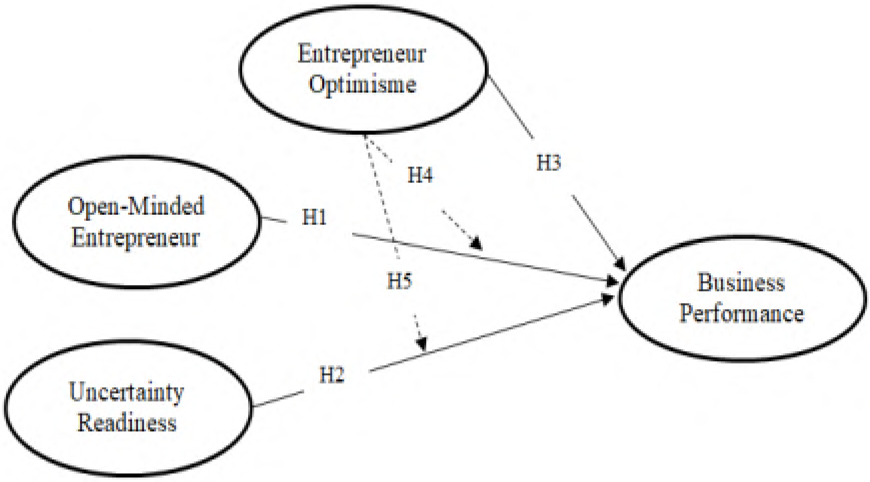
2. 5. HYPOTHESIS DESIGN

Business performance in food and beverage SMEs is determined by many pillars, including strategic accuracy, product commodities under market desires, and communication in the marketing layer (Abdul Lasi & Rahim, 2021; Adistia & Sanaji, 2022; Aryani & Tuti, 2023; Aswan, 2023; Meisya & Surjasa, 2022; Taneo et al., 2017; Upe & Aswan, 2022). Apart from strategic matters, there are also other indications that influence SME business performance. For example, elements inherent in the entrepreneur's background (Ghannad & Andersson, 2012; Jo & Lee, 1996). In SME business, the role of entrepreneurs is very large in operations in the field (Erlangga et al., 2022; Lin et al., 2022; Peng et al., 2020; Teruel-Sánchez et al., 2021).

Universally, an entrepreneur must emphasize an open-minded attitude. By integrating attitudes like that, it will enable entrepreneurs to exchange ideas and opinions interactively with anyone. By incorporating new ideas or innovations into business learning, you can facilitate optimal business performance. Somwethee et al. (2023) highlight that entrepreneurs' open-mindedness influences business performance through their ability to recognize opportunities and choose changes in the business environment. Therefore, by paying attention to innovation in new markets, the open-mindedness inherent in entrepreneurs can grow business performance systematically (Al-Abrow et al., 2023).

Change is an absolute thing that must happen in business. In order to survive change, entrepreneurs always take a holistic attitude towards change itself. Broadly speaking, uncertainty readiness is readiness to face any existing changes (Diwanti & Nawai, 2022). In adapting to these changes, the right strategy needs to be created to maintain business performance. At the same time, positive stigma needs to be directed at business transformation. Optimistic entrepreneurship is a crucial part, considering that entrepreneurs who think optimistically always look positively at their business journey. Also, always be calm when cornered, enthusiastic in building resistance to pressure, and able to encourage the team to continue to protect each other even in difficult conditions.

Figure 1. Conceptual framework



Source: Developed from past studies and Authors

Some references also found gaps in the proposed concept design. One of them is from Al-Abrow et al. (2023), Alteren & Tudoran (2019), Meng & Wang (2024), and Michna & Kmieciak (2020) claim that there is a negative connection between open-mindedness and business performance. This means that open-mindedness that goes beyond boundaries that are not followed by a culture of knowledge sharing, breakthroughs, work culture and environment, adaptive business style, conducive communication, and relational competence, can influence business performance. Another preventive revolution that an entrepreneur must take is uncertainty of readiness to protect business performance. In facing a transitional status such as during and after COVID-19, uncertainty in readiness that is not planned effectively actually increases uncertainty which ultimately hinders business (Arshad & Sabeen, 2021; Ratnawati & Sugiharti, 2023). Another thing is also debated in some studies which explain that excessive optimism will weaken business performance (Amore et al., 2022; Hilary et al., 2016). For an entrepreneur, an attitude of optimism should be able to pave the way in building a business. At this moment, even though optimism looks positive, if it is not created with the best tactics, it is just speculation without direction. On the other hand, optimism reflects the extent of an entrepreneur's motivation to concentrate on business sustainability. In different capacities, if optimism is not built with open mindedness and uncertainty of readiness, it can affect business performance. Chrisanty et al. (2021), Mulyani et al. (2023), Ngek (2015), Schillo et al. (2016), and Surder (2023) state that as long as the priorities of a business only concentrate on openness and future readiness, but are not balanced with inventive optimism, then it is a waste of work. Business performance is an urgent topic to explore because there are many aspects that influence it. One thing that can guarantee business performance is open-minded entrepreneurship, uncertain readiness, and entrepreneurial optimism. Based on the narrative in the literature above, this research is built with a conceptual framework that contains causality between open-minded entrepreneurs, uncertainty readiness, and entrepreneurial optimism on business performance. The reason entrepreneurial optimism is designed as a moderating variable is because entrepreneurial optimism is a vital key in forming open-mindedness and is a motivation for uncertain readiness. Figure 1 summarizes the conceptual framework of the variables. From Figure 1, five hypotheses are offered with the following assumptions:

H1: Open-minded entrepreneurship is related to business performance.

H2: Uncertainty readiness is related to business performance.

H3: Entrepreneurial optimism is related to business performance.

H4: Entrepreneurial optimism is a moderator that strengthens the relationship between open-minded entrepreneurship and business performance.

H5: Entrepreneurial optimism as a moderator strengthens the relationship between uncertainty readiness and business performance.

3. METHODOLOGY

3. 1. METHODS AND DATA ANALYSIS

This research is classified as a quantitative study, which aims to prove several hypotheses created into a conceptual framework model. The data material is primary and collected using a questionnaire instrument. After data collection, the data was recapitulated using descriptive statistics and SEM-PLS via SmartPLS 4 software.

The research sample selected included restaurant and cafe owners who had been operating for at least 3 years. This means that the sample group is a restaurant and cafe business that has been able to survive since the COVID-19 pandemic took place in 2020. The survey was conducted online. The online survey was implemented because the respondents' locations are far apart, so it can make data collection easier, time efficiency, and save costs. The sampling procedure was applied based on simple random sampling, where anyone who met the sample criteria and was willing to fill out the questionnaire distributed online was classified as a research respondent. The survey was conducted from August 2023 to September 2023 with a sample of 128 units from several large cities located in 16 provinces in Indonesia.

The questionnaire is a tool for measuring respondents' perceptions of the specified variables. The questionnaire in this study was divided into two versions. The first version is in the form of questions about the respondent's demographics and the second version is a question to verify the respondent's perception of the research variables including: (1) open-mindedness of entrepreneur, (2) uncertainty of readiness, (3) entrepreneurial optimism, and (4) business performance. In the first part of the questionnaire, the questionnaire is in the form of an open question, while in the second part the perception questions use a semantic differential scale of 1 (not very relevant to what is being done) to 10 (very relevant to what is being done). Then, the stages in the SEM-PLS analysis are as follows: (1) The outer model is the standard for estimating construct validity and reliability which consists of convergent validity tests, discriminant validity tests, and construct validity; and (2) The inner model functions to confirm the goodness of fit for model, including the coefficient of determination test, predictive relevance and hypothesis testing.

Conceptually and practically, SEM-PLS is causal modeling that aims to maximize the explained variance of dependent latent constructs. This approach is in contrast to the Covariance Based-Structural Equation Modeling (CB-SEM) function, which is to produce a theoretical covariance matrix, without focusing on the variance constructed. The philosophical difference between CB-SEM and SEM-PLS lies in testing and confirming theories. If the research orientation is theory development and prediction, then the appropriate method is SEM-PLS. Moreover, SEM-PLS can maximize interpreted differences in dependent constructs, but also to evaluate data quality based on the characteristics of the measurement model. Given SEM-PLS's ability to work efficiently with model complexity, data items, and a much wider range of sample sizes than CB-SEM, SEM-PLS can overcome a variety of specific problems (Henseler et al., 2009). In these situations, when the nature of the model limits the operation of CB-SEM or when the emphasis is more on exploration than confirmation, then SEM-PLS is an appropriate alternative to CB-SEM.

3. 2. VARIABLES

In this research, variables were measured using indicators derived from several previous studies and the results of the researcher's observations and experience. Below are the variables and indicators compiled by the researcher.

Table 1. List of variables

Variables	Type	Indicators/Abbreviations	Modification from
Open-Minded Entrepreneur	Exogenous	Be open to input from other people (OME1) Receive information from anyone (OME2) Personality to accept new ideas and ideas (OME3) Willingness to discuss with other parties (OME4)	Alteren & Tudoran (2019), Bertsch, et al. (2018), Omar (2021), and Rosado-Cubero et al. (2022)
Uncertainty Readiness	Exogenous	Anticipatory of environmental changes (UR1) Innovation to face uncertainty (UR2) Mitigate risks (UR3) Develop strategic steps (UR4)	Kromidha & Bachtiar (2014)
Entrepreneur Optimisme	Exogenous, moderator	There is a way out of every difficulty (EO1) Rise by seeing opportunities in difficulties (EO2) There is always hope for a better tomorrow (EO3) Keep trying in all conditions (EO4)	Belas et al. (2019) and Marliyah (2023)
Business Performance	Endogenous	Turnover oriented (BP1) Profit focused (BP2) Finding new customers (BP3) Prioritize customer satisfaction (BP4) Maintain relationships with loyal customers (BP5)	Selvam et al. (2016) and Van de Ven et al. (2023a, b)

Source: developed from past studies

Variables are divided into three classes, i.e: endogenous variables, moderator variables, and exogenous variables. Exogenous variables are predictor variables that stimulate or reconcile changes or the emergence of endogenous variables. In social experiments, endogenous variables are variables that are a result of or influenced by exogenous variables. Specifically, endogenous variables respond to a described symptom. Besides that, the moderator variable is designed to be an intermediate variable that positions one of the exogenous variables in the mediating relationship between the endogenous variables and the exogenous variables. This variable has a special type that can be measured in assessing this relationship.

3. 3. RESPONDENT PROFILE

Data from a survey of 128 respondents was explored to provide information that is easier to understand. To analyze the characteristics of respondents, frequency distribution analysis was used. Information on the identity of respondents in this study consists of: (1) province, (2) age of business, (3) age of business, (4) number of employees, average turnover. Each of them is summarized in Table 2, Table 3, Table 4, and Table 5.

Table 2. Proportion of respondents by region

Location	Cumulative	Percentage
Bali	2	1.6
Banten	6	4.7
Bengkulu	1	0.8
DKI Jakarta	16	12.5
West Java	15	11.7
Central Java	18	14.1
East Java	6	4.7
West Kalimantan	30	23.4
East Kalimantan	17	13.3
Lampung	1	0.8
Riau	2	1.6
South Sulawesi	1	0.8
Central Sulawesi	1	0.7
North Sumatra	1	0.7
South Sumatra	1	0.8
Yogyakarta	10	7.8
N	128	100

Source: survey results

Of the 128 respondents, 55.5% predominantly came from the island of Java spread across six provinces (DKI Jakarta, Banten, Yogyakarta, West Java, Central Java and East Java). Among the respondents, 36.7% were from the island of Kalimantan, especially in West Kalimantan and East Kalimantan. Table 2 reports that there are 4.7% of the five provinces on the island of Sumatra, namely Bengkulu, Lampung, Riau, North Sumatra and South Sumatra. The remaining 1.6% are from Bali and 1.5% live on the island of Sulawesi (South Sulawesi and North Sulawesi).

Table 3. Business duration

Age (Years)	Cumulative	Percentage
41	1	0.8
39	1	0.7
33	2	1.6
32	1	0.8
28	1	0.8
25	1	0.8
23	2	1.6
22	1	0.8
21	1	0.8
20	1	0.7
19	1	0.8
18	3	2.3
17	2	1.6
16	1	0.8
15	2	1.6
13	5	3.9
12	1	0.8
11	2	1.6
10	3	2.3
9	3	2.3
8	7	5.5
7	9	7.0
6	18	14.1
5	26	20.3
4	19	14.8
3	14	10.9
N	128	100

Source: survey results

Based on business duration, most of the cafes and restaurants that participated in this research were less than 10 years old, reaching 70.1% and the oldest with a business age of around 41 years at 0.8%. Overall, the average composition of food and beverage SMEs is 4.9 years or 3.8% (see Table 3).

Table 4. Number of employees empowered

Employee	Cumulative	Percentage
1	12	9.4
2	27	21.1
3	10	7.8
4	15	11.7
5	19	14.8
6	10	7.8
7	5	3.9
8	11	8.6
9	6	4.7
10	2	1.6
11	2	1.6
12	3	2.3
15	3	2.3
21	1	0.8
25	1	0.8
33	1	0.8
N	128	100

Source: survey results

In comparison, 89.9% of respondents empowered fewer than 10 employees. There are also 21.1% who have 2 employees in their business operations. In this case, the number of employees is beyond the owner. Cafe and restaurant owners are categorized as active in their business operations. Table 4 also illustrates that on average respondents empowered 8 employees (6.3%) to run food and beverage businesses.

Table 5. Turnover

Turnover	Post-Pandemic		Pandemic	
	Cumulative	Percentage	Cumulative	Percentage
< IDR 10 million	41	32	80	62.5
IDR 10 million–IDR 30 million	51	39.8	23	18
IDR 30 million–IDR 60 million	21	16.4	15	11.7
IDR 60 million–IDR 100 million	7	5.5	4	3.1
IDR 100 million–IDR 300 million	6	4.7	5	3.9
> IDR 300 million	2	1.6	1	0.8
N	128	100	128	100

Source: survey results

Table 5 tabulates average turnover in cafe and food businesses. There are four nominal qualifications for the turnover of cafes and restaurants in Indonesia, where in the SME category, the majority of respondents' turnover is below IDR 100 million per month (32%) and 39.8% of respondents have a turnover in the interval of IDR 10 million to IDR 30 million every month.

Apart from that, 16.4% of respondents had a turnover of IDR 30 million to IDR 60 million per month and only a small portion of respondents or around 4.7% of respondents had a monthly turnover of IDR 10 million to IDR 300 million and 1.6% of respondents who generates a turnover of over IDR 300 million from a business of this scale. In other words, the average turnover of this type of SME still shows minimal financial capacity. Compared to during the pandemic, it can be seen that business performance in food and beverage SMEs tends to decline drastically. In contrast to when the pandemic took place, the business performance trend since the pandemic status was transferred to endemic (new normal) has actually increased. Business performance as reflected in the turnover received by the majority of cafe and restaurant entrepreneurs is below IDR 10 million or with a percentage of respondents reaching 62.5%. Based on field data, only 0.8% of respondents showed a turnover value above IDR 300 million.

4. RESULTS

4. 1. DESCRIPTIVE STATISTICS OF QUESTIONNAIRES

In this session, descriptive statistics are used to compile the frequency distribution of respondents' answers in the form of maximum scores, minimum, mean and standard deviation (Utomo et al., 2023). As shown in Table 6, five assessment classifications are determined based on the number of measurement scales. Based on the calculation of the class length for each interval, categories are presented in assessing the calculated average value, namely: (1) very small, (2) small, (3) moderate, (4) high, and (5) very high.

Table 6. Assessment classification for descriptive statistics

Calculated Average	Category
1–2.8	Very small
2.81–4.6	Small
4.61–6.4	Moderate
6.41–8.2	High
8.2–10	Very high

Source: Rahmawati et al., 2022

From Table 6 above, this scale is used as a reference for assessing the results of the questions. Below, write the formula for the class length of each of the following intervals:

$$P = \frac{X_{maks} - X_{min}}{b} \tag{1}$$

Where: P = Class length of each interval, X_{maks} = Maximum value, X_{min} = Minimum value, and b = Class volume.

Table 7, Table 8, Table 9, and Table 10 document respondents' perceptions of each variable. Referring to Table 7, respondents' responses to open-minded entrepreneurs produced an average score of 7.95. This indicates that respondents tend to have a high category of open-minded entrepreneurship. The third indicator in this variable is the highest with the statement "I am interested in knowing about new things that are positive for business" with a mean score reaching 8.02. In contrast, the second indicator in the statement "Taking into account the feedback of the people around me in making decisions" is the smallest with a mean of 7.88.

Table 7. Respondents' perceptions of open-minded entrepreneurs, N = 128

Statement	Minimum	Maximum	Mean	Std. Deviation
I am open to other people's opinions	1	10	7.94	1.38
Taking into account the feedback of the people around me in making decisions	1	10	7.88	1.43
I am interested in knowing about new things that are positive for business	4	10	8.02	1.28
I accept correction from others when I am wrong	3	10	7.97	1.32
Average	**2.25**	**10**	**7.95**	**1.35**

Source: survey results

Empirically, Table 8 displays respondents' responses to uncertainty with an average mean score of 8.11 or cafe and restaurant SMEs are considered to have high readiness uncertainty. The second and fourth indicators in the statement "We carry out innovations to face uncertainty in the business environment, such as COVID-19" and "We develop strategic steps to take action to keep the business surviving" are indicators with a mean of 8.14. On the one hand, the indicator with the smallest mean score of 8.07 is the first indicator with the statement "We took anticipatory steps when changes occurred that had an impact on business since the government announced that the pandemic outbreak was starting to enter Indonesia".

Table 8. Respondents' perceptions of uncertainty readiness, N = 128

Statement	Minimum	Maximum	Mean	Std. Deviation
We took anticipatory steps when changes occurred that impacted business since the government announced that the pandemic outbreak had begun to enter Indonesia	4	10	8.07	1.56
We carry out innovations to face uncertainty in the business environment, such as COVID-19	3	10	8.14	1.52
We made plans for the worst	4	10	8.1	1.52
We develop strategic steps to take action to keep the business surviving	3	10	8.14	1.54
Average	**3.5**	**10**	**8.11**	**1.54**

Source: survey results

Respondents' responses to optimistic entrepreneurs produced an average of 8.4. This indicates that respondents tend to have very high entrepreneurial optimism (see Table 9). Uniquely, the indicator with the highest mean score is the third indicator with the statement "I am optimistic that tomorrow new hope will emerge for better conditions ", where the score reached 8.45. Other descriptive statistics show that the first indicator has the lowest mean score (8.35) with the statement "Right now is a difficult time, but I believe that there will always be a way out of all existing problems."

Table 9. Respondents' perceptions of entrepreneur optimism, N = 128

Statement	Minimum	Maximum	Mean	Std. Deviation
Right now is a difficult time, but I believe that there will always be a way out of all existing problems	3	10	8.35	1.54
This pandemic has affected all businesses, but I believe there are still opportunities if you remain faithful	4	10	8.42	1.5
I am optimistic that tomorrow new hope will emerge for better conditions	4	10	8.45	1.51
Doing business definitely has risks (one of which is the effect of this pandemic), but I will still accept this risk with grace	4	10	8.39	1.45
Average	**3.75**	**10**	**8.4**	**1.5**

Source: survey results

Through Table 10, it is evident that the average mean score of respondents' responses to business performance reached 7.77 or it was concluded that business performance in cafes and restaurants was running well. Among the five indicators in this variable, it can be seen that the second indicator through the statement "We have loyal customers" is the indicator with the largest mean of 8.04. However, the fifth indicator is the indicator that has the lowest mean score reaching 7.41 with the statement "We were able to get a positive net profit".

Table 10. Respondents' perceptions of business performance, N = 128

Statement	Minimum	Maximum	Mean	Std. Deviation
The number of our customers continues to increase over time	4	10	7.79	1.33
We have loyal customers	4	10	8.04	1.34
Customers are always satisfied with products and services	4	10	8.02	1.32
During this time, we have gained significant business income	4	10	7.59	1.28
We are able to get a positive net profit	4	10	7.41	1.36
Average	**4**	**10**	**7.77**	**1.33**

Source: survey results

4. 2. MODEL FEASIBILITY

In this section, predictions are made regarding the feasibility of the model (inner and outer). The stages in model feasibility include: (1) convergent validity, (2) discriminant validity, (3) construct reliability, (4) coefficient of determination, and (5) predictive relevance. Especially in the evaluation of structural models or inner models, it is intended to identify goodness of fit which consists of coefficients of determination and predictive relevance.

First, evaluation of construct validity is carried out by looking at convergent validity. Convergent validity is identified through factor loading scores and Average Variance Extracted (AVE). An instrument is said to meet convergent validity testing if it has a loading factor and AVE with standards above 0.5. The results of convergent validity and discriminant validitiy testing are presented in Table 11. All indicators contained from Table 11 claim that the loading factor score is more than 0.7. The AVE score also shows above 0.5. Based on convergent validity, all these indicators are categorized as valid in forming the variables.

Table 11. Convergent validity and discriminant validity

Variables	Indicators	Factor Loading	Cross Loading	AVE
Uncertainty Readiness	UR1	0.913	0.835	0.858
	UR2	0.928	0.893	
	UR3	0.939	0.878	
	UR4	0.925	0.919	
Entrepreneur Optimism	EO1	0.935	0.901	0.878
	EO2	0.941	0.680	
	EO3	0.927	0.724	
	EO4	0.945	0.839	
Open-Minded Entrepreneur	OME1	0.897	0.825	0.791
	OME2	0.887	0.805	
	OME3	0.876	0.814	
	OME4	0.898	0.822	
Business Performance	BP1	0.835	0.805	0.784
	BP2	0.893	0.913	
	BP3	0.878	0.928	
	BP4	0.919	0.939	
	BP5	0.901	0.925	

Source: survey results

Second, discriminant validity is centered on cross loading with the criterion if the cross loading score on a variable is higher than the indicator correlation on other variables. With these standards, the indicators are classified as valid in forming the corresponding variables. Through cross loading measurements, it can be seen that overall the indicators of all variables (bold font) form a loading score that is greater than the specified loading standard. Thus, the existing statistical output concludes that from the discriminant validity test, each indicator is able to measure the latent variable that corresponds to the indicator.

Third, to calculate construct reliability using Cronbach alpha and composite reliability. By the test format, the proposition is that if the composite reliability score is above 0.7 and the Cronbach alpha score is more than 0.6, then the model construct is concluded to be reliable. Next is Table 12 which presents a diagram of calculating composite reliability and Cronbach alpha, where all variables have Cronbach alpha values above the criteria with composite reliability values which are also above statistical standards, so that all indicators are concluded to be reliable in measuring the variables. Among the four variables, both in terms of Cronbach alpha and composite reliability, entrepreneurial optimism is the most superior with scores reaching 0.954 and 0.966, while the variables with the lowest Cronbach alpha and composite reliability scores are 0.912 and 0.938.

Table 12. Construct reliability and coefficient of determination

Variables	Cronbach Alpha	Composite Reliability	R Square	R Square Adjusted
Business Performance	0.931	0.948	0.950	0.948
Entrepreneur Optimism	0.954	0.966	–	–
Open-Minded Entrepreneur	0.912	0.938	–	–
Uncertainty Readiness	0.945	0.960	–	–

Source: survey results

Fourth, the coefficient of determination (R^2). The R^2 value is used to diagnose the ability of endogenous variables to explain the diversity of exogenous variables or determine the contribution of exogenous variables to endogenous variables. As shown in Table 12, the adjusted R^2 diagram shows that business performance is 0.948. It is articulated that the variation in business performance can be explained by two endogenous variables (open-minded entrepreneur and uncertain readiness) which are moderated by entrepreneurial optimism reaching 94.8%. There is 0.52 or 5.2% contribution from other variables not discussed in this research. Furthermore, based on the R^2 diagram, it was found that open-minded entrepreneurs and uncertain readiness moderated by entrepreneurial optimism influenced business performance by 0.95 (95%). Meanwhile, 0.05 or 5% is a factor outside the model.

Table 13. Discriminant validity based on cross laoding

Model	Sum Square Error/SSO	Sum Square Error/SSE	Q^2 (1-SSE/SSO)
Business Performance	169	640	7.767

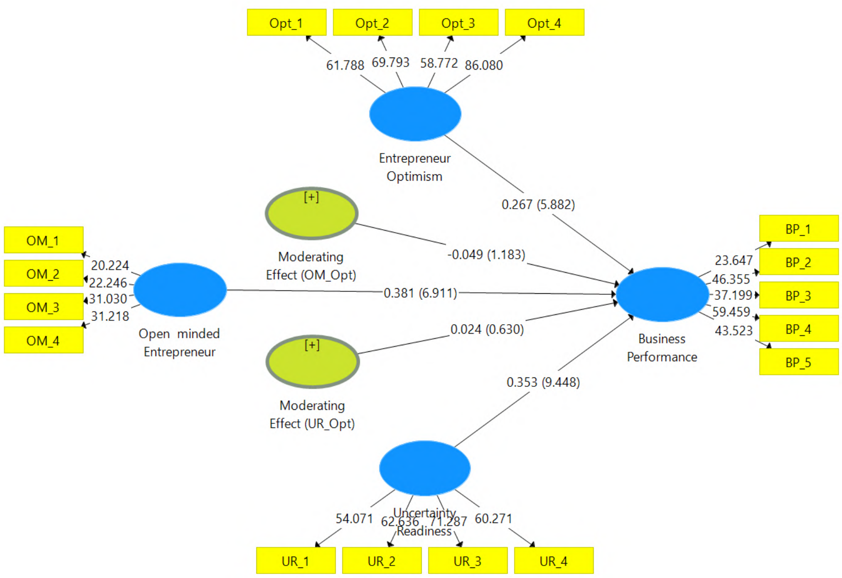
Source: survey results

Fifth, the score listed as predictive relevance (Q^2) is applied to assess how well the observations are produced by the model and also to estimate its parameters. If the score on Q^2 is higher than 0 (zero), it indicates that the model prepared is classified as good, while the Q^2 score is less than 0 (zero) indicating that the model lacks predictive relevance. Through Table 13, it is detected that exogenous variables with a Q^2 score greater than the statistical standard or research model are classified as good.

4. 3. HYPOTHESIS TEST

Hypothesis testing is applied to evaluate whether there is a direct effect between exogenous variables on endogenous variables and indirect effects between exogenous variables on endogenous variables through mediator variables. The criteria for testing direct and indirect relationships are determined by the T-statistics score, which must be greater than the T-table (1.96) or the ρ-value below significant alpha 5% (0.05). If these assumptions are met, it can be concluded that there is a significant relationship between the variables. Figure 2 and Table 14 explain the causality in the model tested.

Figure 2. Path in PLS



Source: survey results

Table 14. Summary of hypothesis test

Linkages	Coeff.	T-Statistics	Prob.
Open-Minded Entrepreneur → Business Performance	0.381	6.911	0.000
Uncertainty Readiness → Business Performance	0.353	9.448	0.000
Entrepreneur Optimism → Business Performance	0.267	5.882	0.000
Open-Minded Entrepreneur → Entrepreneur Optimism → Business Performance	-0.049	1.183	0.237
Uncertainty Readiness → Entrepreneur Optimism → Business Performance	0.024	0.630	0.529

Source: survey results

Through direct and indirect testing, five important findings were explained. First, open-minded entrepreneurship influences business performance. With a T-statistics score of 6.911 and a ρ-value reaching 0.000, there is a significant influence on the relationship between open-minded entrepreneurship and business performance. Second, uncertainty about readiness affects business performance. Here, the T-statistics score shows 9.448 and the ρ-value is 0.000, which indicates that the relationship between uncertainty readiness and business performance is significant. Third, entrepreneurial optimism influences business performance. The T-statistics score is 5.882 with a ρ-value of 0.000. Thus, there is a significant relationship between uncertainty of readiness and business performance. Fourth and fifth, both open-minded entrepreneurs and uncertain readiness moderated by optimistic entrepreneurs are concluded to have no significant impact on business performance. Of the two, they were found to have T-statistics scores (1.183 and 0.640) and p-values (0.237 and 0.529) below statistical criteria. In other words, entrepreneurial optimism does not act as a moderator in the relationship between open-minded entrepreneurship and uncertain readiness on business performance.

5. DISCUSSION

Research has proven the five hypotheses proposed in the conceptual framework. Of the five, three hypotheses were accepted and the other two hypotheses were rejected. The two hypotheses that were rejected were the hypotheses that placed entrepreneurial optimism as a moderator variable. In the first hypothesis, it was explained that "open-minded entrepreneurship is related to business performance" and was proven to be accepted. Business in the food and beverage sector is a dynamic type of business that has a small entry barrier. Nowadays, competitors in this business are very tight because almost all entrepreneurs can enter this business without obstacles. With a large number of competitors, the right strategy formulation is needed to have resilience, be able to develop, and have a good work ethic in maintaining business excellence.

An entrepreneur is required to always be updated on all obstacles that occur, even in extreme conditions. Apart from that, he is also able to think objectively about information related to his business. Naturally, this information can take the form of complaints and comments from customers or business tips and news from various information sources that can be accessed online or offline. Entrepreneurs who dedicate their business with an open mind will really appreciate all forms of information obtained to be able to maintain business performance. This is different from closed-minded entrepreneurs who tend to be narrow-minded, lose enthusiasm, and tend to ignore the latest information.

Open-minded entrepreneurs are proven to be able to bring cafe and restaurant SMEs to achieve better business performance. Especially in the midst of a pandemic attack on this planet, including in Indonesia. The majority of entrepreneurs in this business scope are required to find alternative strategies that correlate with regulations issued by the government in handling COVID-19. Thus, freedom of complex thinking prioritizes input from various parties and is open to new ideas for new ways to support its business. From several articles, it was found that entrepreneurs who think openly can improve business performance (Chavez, 2016; Farida & Setiawan, 2022; Tseng & Tseng, 2019). Open-minded entrepreneurs explore new information and ideas and have the ability to anticipate problems.

Another manuscript from Peljko & Antoncič ˇ (2022) explains that entrepreneurs with an open-minded nature can automatically boost business performance by increasing creativity and interacting with new markets. Entrepreneurs with an open-minded character, relatively avoid conservative thinking or are open to highlighting new ideas that are going viral. Being open minded really determines business performance in any field. Apart from speed of adaptation to change, it also stimulates innovation and creativity. Open minded provides stimulation for entrepreneurs to learn new things that were not known before. This becomes problem solving from the root of the problem being faced. Entrepreneurs will be encouraged to create new products with mature mastery.

Another reasonable argument regarding open mindedness contributing to increased business performance is the more effective team development. Open-minded entrepreneurs can more easily form teams from various backgrounds, especially experiences that will enrich their perspective in looking at a case. In this case, it is important to remember that it has an influence on the decision-making process. With complete information sources, it also encourages a comprehensive viewpoint with competent risk management.

For the second hypothesis, namely "uncertainty readiness is related to business performance" and the results are accepted. Even though there is a lot of uncertainty in the business world, it is not impossible to change things according to the demands of the times, environment and market share. Likewise in food and beverage scale businesses. With a dynamic pattern that is oriented towards basic human needs, now businesses in this scope must focus on market habit and market style based on segmentation. For this reason, what entrepreneurs who work in cafe and restaurant SMEs need to encourage is agility towards all changes in tastes, especially customer desires. Besides that, changes to a dynamic business environment or what is generally called "market driving", allows for wise preparedness.

Changes in the business environment that can disrupt business continuity at any time require integrated adjustments. As explained in this study, readiness to face various changes has implications for business performance. In line with previous research which found that companies that have high uncertainty readiness tend to have better business performance compared to companies with low uncertainty readiness systems (Holopainen et al., 2022; Kafetzopoulos et al., 2020; Sharfaei et al., 2023; Tjahjadi et al., 2024). Uncertainty readiness can help companies find and overcome risks or opportunities that arise in the business environment. From the scientific work revealed by Korucuk et al. (2023) and Tran et al. (2022) found that uncertainty in readiness has an impact on business performance by realizing the effectiveness of supply chain management. In turn, companies that have large levels of readiness uncertainty are relatively able to overcome uncertainty in the supply chain and produce positive performance.

However, each company has unique conditions with different business conditions, so the impact of uncertain readiness on business performance can vary depending on the context in which it is carried out. Business in the food and beverage sector is also determined by style and trends. As has happened in Indonesia recently, where Korean food is very popular with young people, so cafes and restaurants have emerged that serve Korean food in various segments starting with varying prices for each portion. Apart from that, in the case of types of drinks, such as mixue ice cream outlets, which are quite popular and have become the consumption habits of many groups. But, local products have adapted to market tastes to adopt today's food and drink styles. The emergence of Korean food and beverage trends, such as mixues or similar, is a condition that triggers a shift in the food and beverage business. When the number of products abandoned by consumers increases, this means that variations of a new product are not sufficiently prepared, so business performance declines drastically.

The third hypothesis states that "entrepreneur optimism is related to business performance", where the statistical output shows that the hypothesis is accepted. Why can entrepreneurs who are full of optimism bring better business status? To answer this question, two landscapes were developed. First, constructive tactics. Facts in the field show that entrepreneurs with high optimism in seeing many opportunities in every situation or situation they are facing tend to have positive desires through initiative and strategic diversification. Second, as an illustration, for example the global recession that hit Indonesia due to the COVID-19 pandemic in 2020. With many food and beverage entrepreneurs closing their businesses, either temporarily, permanently, or switching to other business fields, this has actually triggered some entrepreneurs who remain. They believe that the economic disruption will soon pass and continue to struggle to get out of the burden of the problems they are facing.

Optimism that is expressed positively has the potential to become a concern for other people, especially attracting team members to work under any conditions. Even in stressful situations, entrepreneurs can rely on optimism and transmit it to their business organizations. The growing sense of optimism also reflects the responsibility of future leaders to be able to overcome greater challenges. Investments that link optimism to business performance have been carried out by Arakawa & Greenberg (2007) and Qian & Miao (2017) who found that optimistic entrepreneur behavior can influence an organization's business performance. Optimistic entrepreneurs tend to be more enthusiastic about developing and regenerating their business in the future. In a similar theme, it is shown that entrepreneurs' optimism supported by skills can influence business performance (Bergen & Bressler, 2011; Bronson et al., 2006; Brown, 2017; Rotich, 2020). Technically, entrepreneurs who are optimistic are a signal of courage to try new things that will have an impact on the continuity of the business ecosystem. This is no exception in the case of excessive levels of optimism, it can actually be detrimental to company performance if it is not combined with ethics, morals and appropriate actions. Why can excessive optimism reduce business performance? In this realm, optimism that is too high can trigger an entrepreneur to become weak in supervision, for example not being serious enough in responding to threats that have the potential to reduce business performance. Even so, an entrepreneur still needs optimism to foster an entrepreneurial spirit (Giningroem et al., 2021). With good control of optimism, pessimism will slowly decrease. Being careful in acting and preparing future agendas can enrich the experience.

The fourth and fifth hypotheses explain that "entrepreneur optimism is a moderator that strengthens the relationship between open-minded entrepreneurs and entrepreneurial optimism on business performance", which is contrary to the statistical results and both hypotheses are rejected.

In this framework of thinking, optimistic entrepreneurs are expected to be an option to drive optimistic entrepreneurs towards business performance which is logically acceptable. This cannot be separated from the optimism factor which can help entrepreneurs to remain sensitive and serious in running their business when facing challenges. Meanwhile, the open-minded aspect allows entrepreneurs to accept new input, learn innovative ideas, and explore strategies according to market flows. At the same time, over-optimism has the potential to reduce an entrepreneur's critical, analytical and alert attitude.

It is important for entrepreneurs to check and maintain a balance between positive optimism and a critical attitude in business management. Optimism that is not accompanied by a critical attitude and fresh analytical skills can trigger irrational management, resulting in overlapping decision making. Thus, it cannot be denied that over-optimism backfires on business performance if it is not aligned with the right strategy and action plan. For example, entrepreneurs who dare to take risks without considering potential losses can threaten greater material losses, including financial.

The fifth hypothesis, which examines the role of entrepreneurial optimism as a moderator variable in the relationship between uncertainty readiness and business performance, is also not proven to have an effect. Entrepreneurs' optimism that is too high can make entrepreneurs careless in managing their business. Although optimism is necessary, this ambition must be shown wisely, bridging by a stable awareness in overcoming all business obstacles.

In the midst of business conditions full of uncertainty, companies that have high readiness uncertainty have better business performance which is followed by entrepreneur associations which are also accompanied by positive optimism. Optimistic entrepreneurs tend to be more confident in facing challenges and are relatively able to take advantage of opportunities. In this discussion, it is emphasized that if entrepreneurs have a tendency to be over-optimistic, then the ability to interpret uncertainty in readiness cannot be fully actualized. This also closes an alert attitude towards major possibilities that an entrepreneur cannot predict. In the end, it further reduces the positive impact of uncertain readiness on business performance.

From the last two hypotheses which test the moderator effect (entrepreneur optimism) on the influence of open-minded entrepreneurship and uncertain readiness on business performance, it can be understood that entrepreneurs must have optimism. Yet, the point of concern is that when optimism appears without wise control, it will boomerang and kill the business. Poor business performance occurs if critical attitudes and analytical abilities decrease.

6. CONCLUSIONS

This research was conducted to investigate the influence of open-minded entrepreneurship and uncertain readiness on business performance which is mediated by entrepreneurial optimism. Although studies that focus on SME cafes and restaurants that provide food and drinks have been highlighted previously, few have linked the function of open mindedness, uncertain readiness, or optimism in reviewing entrepreneurs' ability to adapt to the business environment. Then, the role of optimism in the relationship between open mindedness and uncertain readiness to support business is a novelty that is not widely discussed. From existing research, two main points were found as follows: (1) open-minded entrepreneurship, uncertain readiness, and entrepreneurial optimism have been proven to improve business performance; and (2) open-minded entrepreneurs or uncertain readiness have no impact on business performance through entrepreneurial optimism.

All studies have weaknesses, this research is no exception. To complement existing limitations, recommendations for further research need to sharpen several important points as follows: (1) Because the survey was conducted online (Google form), it gave rise to different justifications from respondents in understanding the question items. Therefore, sample mapping in the field can be implemented collectively via other online applications such as WhatsApp. With the existing sample distribution, this application will also make it easier for targeted respondents and can collect larger survey data to be extracted into analytical tools; (2) The quality of the data produced through online surveys is less than ideal, so that when the data is processed, some of it is difficult for respondents to understand. Thus, question items need more implicit questions to be understood; and (3) Apart from focusing on cafe and restaurant SMEs, other research objects outside of this need to be highlighted or comparative investigations carried out. With panel data through the involvement of different analysis objects, it allows novelty in the marketing management discipline.

Based on the results of the analysis, practical recommendations for cafe and restaurant SMEs in Indonesia are suggested. Entrepreneurial optimism has proven to fail in mediating the relationship between open-minded entrepreneurship and uncertain readiness on business performance. Seeing that the impact is not significant, the government needs to develop a program that can have a direct impact on growing SMEs, especially providing incentives for SME cafes and restaurants at the lower middle level. With financial assistance, entrepreneurs in cafe and restaurant SMEs in underdeveloped categories can improve their services, skills and experience. Financial support is a solution that can be input into SME development planning under the auspices of the government. Apart from material things, there are also non-financial factors such as optimism which greatly determine business sustainability. Positive optimism can be formed through training, monitoring and evaluation. Entrepreneurs need support from external parties in channeling friendly optimism towards their business environment to continue to exist.

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NS global economics
ECONOMICS
Innovative and Economics Research Journal
Volume 12, No. 1, 2024
www.economicsrs.com

THE INFLUENCE OF THE CAPITAL MARKET (FINANCIAL INSTRUMENTS) ON ECONOMIC GROWTH IN KAZAKHSTAN AND CIS COUNTRIES

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Received 09.01.2024. | Sent to review 19.01.2024. | Accepted 06.04 .2024.

Original article

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JEL Classification: A1,C3, C5

Doi: 10.2478/eoik-2024-0010

UDK: 336.76:005.334(574)

ABSTRACT

Econometrics is a branch of economics that uses mathematical and statistical methods to study quantitative and qualitative relationships within economic phenomena. The purpose of this article is to study the impact of the capital market (financial instruments) on economic growth in Kazakhstan and the CIS countries through an understanding of the concept of "econometrics". The task of the study is to determine the dependence of gross domestic product as a resultant factor over the past 20 years. Methods. The article determines the assessment of the impact of financial factors on economic growth in the short term. An econometric model was used for this purpose. The resulting factor was the gross domestic product over the past 20 years. Results. The results indicate that the capital market influences economic growth in Kazakhstan and the CIS countries. This paper presents a model of the GDP function for the economy of Kazakhstan. In the course of the study, coefficients and variables of the model were estimated to predict the level and future changes in the country's GDP. Thus, the size of the capital market (Y1) depends on the following variables tested in the model: the number of securities issuance transactions; the volume of securities issuance transactions; the number of transactions of non-residents with shares at the secondary auction of KASE; the rate of change of shares of leading issuers on KASE

Keywords: *econometrics, methods, models, Gross domestic product, capital markets, securities market*

1. INTRODUCTION

The role of finance in economic activity is a topic that has long been of interest to economists and government agencies. Indeed, in the twentieth century, prominent authors talked about the benefits of financial development for economic development.

However, the role of finance in economic growth models has long been ignored. Indeed, Keynesian theorists (Easterly & Levine,2002), for whom monetary and financial phenomena are crucial to explain the level of activity, are traditionally interested not in growth (a long-term phenomenon), but in developing short-term models (Narziev, O., 2021; Eswar et al., 2007). More recent work carried out within the framework of endogenous growth models will aim to highlight the direct positive relationship between financial development (the development of financial intermediaries and capital markets) and economic growth. This affects economic growth by increasing productivity and capital efficiency.

The purpose of this paper will be explored through understanding the concept of "econometrics". Econometrics is a branch of economics that utilizes mathematical and statistical techniques to study the quantitative and qualitative relationships within economic phenomena (Greenwood & Jovanovic, 1990). This field's contemporary scope was outlined by the Econometric Society, which emphasized the integration of statistics and mathematics to advance economic theory as its primary objective. Econometrics is divided into two main areas: theoretical econometrics, which examines the statistical characteristics of estimators and testing methods, and applied econometrics, which applies these methods to evaluate economic theories. It offers tools for economic measurement and methodologies for estimating model parameters at both microeconomic and macroeconomic levels. Additionally, econometrics is widely employed in forecasting economic trends, applicable across the broader economy and within individual businesses, positioning it as a crucial component of economic theory, alongside macroeconomics and microeconomics (Caporale et al.,2005).

An assessment of influence of financial factors on economic growth in the short-term period should be carried out. For this purpose, the econometric model will be made.

Gross domestic product acts as a resultant factor for the last 20 years (Y). As the variables having impact on a resultant factor, the following variables act: size of the market of the capital, billion tenge, Y1; size of the market of securities, billion tenge, Y2. Size of the market of the capital, billion tenge (Y1) depends on the following variables tested in the model: number of operations on issue of securities; the volume of operations on issue of securities; number of operations of nonresidents with actions at the secondary auction of the KASE; rates of change of actions of leading issuers at the KASE. Size of the market of securities, billion tenge (Y2) depends on the following variables: primary placement at the KASE; volume of the credit market, billion tenge; volume of the insurance market, billion tenge; size of the market of derivative financial instruments, billion tenge.

2. LITERATURE REVIEW

A literature review on the influence of the capital market and financial instruments on economic growth in Kazakhstan and CIS countries entails an examination of scholarly articles, reports, and studies exploring various aspects of this relationship (Review of the financial market,2021; Review of the financial market, 2022). The review highlights theoretical foundations, empirical findings, and key discussions within the context of emerging market economies such as those in the CIS region. Here's a summary based on existing literature:

Theoretical Framework:

1. Modigliani-Miller Theorem on Capital Structure: Originally devised to comprehend the effects of debt and equity on a firm's value, this theorem establishes fundamental principles for understanding the functioning of financial markets in efficiently allocating resources (Ahmeti, F. & Prenaj, B.,2015).

2. McKinnon-Shaw Hypothesis: This hypothesis proposes that financial liberalization, leading to the development of financial markets, contributes to economic growth by improving savings rates, investment decisions, and technological advancements (Koshkina et al.,2015).

Empirical Findings:

1. Role of Financial Markets in Resource Allocation: Studies focusing on Kazakhstan and CIS countries highlight the capital market's role in facilitating efficient resource allocation, emphasizing the significant impact of stock markets and bond markets in mobilizing savings for investment in productive assets (Shakeyev, S. et al.,2023).

2. Impact of Financial Instruments on Economic Growth: Research indicates that a wide range of financial instruments, including derivatives, equity, and debt securities, play a vital role in hedging risks, diversifying investment portfolios, and enhancing liquidity, thereby supporting economic growth (Bencivenga, V.& Smith, B.,1991).

3. Regulatory Environment and Market Development: The literature underscores the importance of a robust regulatory framework in fostering market confidence, protecting investors, and ensuring market stability, which are crucial for the development of capital markets and their contribution to economic growth (Beck, T.& Levine, R.,2004; Chubrik, A.,2002; Aziakpono, M.,2011).

3. METHODS

3. 1. DATA SOURCES

An econometric model is a statistical or mathematical model that represents the relationship between two or more variables. Its use allows you to evaluate the influence of one variable on another and/or make predictions about the future value of variables.

Table 1. Econometric model

Year	Gross domestic product, billion tenge, Y	Size of the market of the capital, billion tenge, Y1	Number of operations on issue of securities	The volume of operations on issue of securities, billion tenge	Number of operations of nonresidents with actions at the secondary auction of the KASE	Rates of change of leading actions of leading issuers at the KASE	Size of the market of securities, billion tenge, Y2	Primary placement at the KASE	Volume of the credit market, billion tenge	Volume of the insurance market, billion tenge	Size of the market of derivative financial instruments
	Y	Y1	Variables for Y1				Y2	Variables for Y2			
2006	162	49878	10172	110	98000	19	10580	9	7141	471	21980
2007	611	50420	11450	98	87000	18	11045	8	7420	470	22090
2008	1429	51770	12390	125	101000	12	11520	9	7880	488	23101
2009	2019	52888	13570	101	89000	12	11960	35	8370	496	22450
2010	2343	52890	14400	112	87900	8	12111	9	8452	530	23780
2011	2630	52880	15000	87	88700	16	12880	36	9540	590	24110
2012	4823	53897	13800	102	112013	1	12780	4	9880	598	24890
2013	7306	53961	12100	89	115000	7	13110	19	10470	670	25120
2012	7944	53290	11200	95	110000	2	13520	16	10450	660	25870
2013	10831	54870	13500	103	80900	5	14199	17	11945	695	26111
2014	13208	54930	14800	115	95600	9	14660	8	11094	710	26489
2015	17027	55987	12300	118	95400	6	14321	48	12110	732	27550
2016	21610	56482	14500	121	87890	2	14980	12	12870	754	28450
2017	26917	56890	12800	126	98700	3	14870	8	13154	798	29740
2018	32248	57420	14780	124	87400	4	15110	9	13298	801	29880
2019	41277	57880	12357	131	88900	3	15420	8	14170	821	30120
2020	38877	58370	12450	145	87980	10	15780	19	14381	870	30332
2021	46322	59072	16880	118	84750	4	16761	8	15267	991	30937
2022	55329	61234	15900	98	89570	5	19609	28	20121	1267	32484
2023	62357	66061	15400	92	88740	11	11567	23	24483	1479	35492

Source: Review of the financial market, 2022

In this case, two groups of variables Y1 and Y2 will be studied, which will allow us to estimate the dynamics of GDP in a chronological framework from 2006 to 2023. Table 1 represents the econometric model.

3. 2. MODEL SPECIFICATION

Building a model based on regression analysis of the selected parameters allows to establish and formalize the relationship between different indicators in the form of an equation:

$$\hat{Y}_i = b_0 + b_1 X_{1i} + b_2 X_{1i}^2 \quad (1)$$

Running a regression analysis, Excel provides standard output that is important for interpreting the results of model. These results are presented in tabular form and are often referred to as Table 2 in academic papers and publications. The content of this message includes, but is not limited to, the following key metrics:

1. Multiple R – correlation coefficient of R;
2. R2 - determination coefficient R2;
3. Adjusted R2
4. Standard error;
5. Observations.

Table 2. Correlation

	Column 1	Column 2	Column 3	Column 4	Column 5
Column 1	1				
Column 2	0,595791	1			
Column 3	0,129059	-0,08987	1		
Column 4	-0,31015	-0,44792	-0,24857	1	
Column 5	-0,40246	-0,29092	-0,24236	-0,18373	1

Source: by authors

At the next stage of the correlation analysis, multiple correlation coefficients were studied and checked for significance (Table 3).

Table 3. Co-variation

	Column 1	Column 2	Column 3	Column 4	Column 5
Column 1	14010298				
Column 2	3744041,2	2818684,1			
Column 3	7339,7	-2292,375	230,85		
Column 4	-10696555	-6929030,2	-34799,25	84898313	
Column 5	-7946,625	-2576,5325	-19,425	-8930,275	27,8275

Source: by authors

Since the analysis of the correlation coefficient matrix revealed the presence of multicollinearity, it makes sense to use an algorithm for step-by-step inclusion of variables to obtain the optimal regression equation. To do this, the explanatory variable with the highest correlation coefficient with the dependent variable (0.66) was included in the model (Table 4).

Table 4. Regression Statistics

Multiple R	0,661146
R Square	0,437115
Adjusted R Square	0,287012
Standard Error	3242,673
Observations	20

Source: by authors

Table 5 contains the results of the dispersion analysis which is used for the control of R2 significance:

df column – the number of degrees of freedom. For Regression row, the number of the degrees of freedom is equal to the number of factor indications of the regression equation; for Residuals row, this number equals the number of observations minus the number of variables in the regression equation (m+1).

SS column – the sum of squared errors. For the Regression row this is the sum of squared deviations of theoretical data from the average - RSS; for the Residuals row this is the sum of squared deviations of empirical data from the theoretical – ESS.

MS column is calculated as SS/df.

F column is the calculated value of Fisher's criterion.

F significance is the value of significance corresponding to the calculated value of F.

Table 5. F significance

	df	SS	MS	F	Significance F
Regression	4	122482092	30620523	2,912101	0,0574682
Residual	15	157723875	10514925		
Total	19	280205967			

Source: by authors

Table 6 contains the values of regression coefficients bi and their statistical estimations. The columns have the following interpretation:

Coefficients – the values of bi coefficients;

Standard error - Sbi standard errors of the coefficients bi;

t-statistics – the values of t-criterion calculated as bi/Sbi;

P-value – the levels of significance corresponding to the calculated value of t-statistics;

Lower 95% and upper 95% - lower and upper bounds of confidence intervals for the regression coefficients bi.

Table 6. Coefficients of the model for Y1

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	46697,24	21040,73	2,219374	0,0423	1849,988	91544,49	1849,988	91544,49
X Variable 1	1,023668	0,587354	1,742847	0,101817	-0,22825	2,275583	-0,22825	2,275583
X Variable 2	16,90115	56,90352	0,297014	0,770529	-104,386	138,1881	-104,386	138,1881
X Variable 3	-0,05624	0,107818	-0,52165	0,60953	-0,28605	0,173566	-0,28605	0,173566
X Variable 4	-197,038	173,5029	-1,13565	0,273925	-566,851	172,7746	-566,851	172,7746

Source: by authors

4. RESULTS

A T-test is a statistical tool that checks if there is any difference or correlation between two different datasets. The t-test formula verifies this by comparing the average values of both data sets presented in Table 7. In order to check whether our model is appropriate, good or bad, we must make some tests.

R^2

R Square is almost 1 => as the value of R square lies between 0 and 1 and is closer to 1, then our model is well explained and our regressors are chosen correctly and they explain regressants well enough.

F-test

Femp > Fcrit => R square formed not under the influence of random factors. Significance F < 0.05 => Model has a good explanatory ability.

Table 7.T-Test

	Coefficients	Standard Error	t Stat
Intercept	46697,24	21040,73	2,219374
X Variable 1	1,023668	0,587354	1,742847
X Variable 2	16,90115	56,90352	0,297014
X Variable 3	-0,05624	0,107818	-0,52165
X Variable 4	-197,038	173,5029	-1,13565

Source: by authors

Tcrit is equal to 2,13145. Absolute values of t Stat of $\beta 1$ and βn > tcrit, then our coefficients are significant.

In addition, the Goldfeld-Quandt test was performed to determine whether heteroskedasticity is present (Table 8) using the following equation:

$$Y(t) = 46697{,}24 + 1023668 * X1(t) + 16{,}90115 * X2(t) - 0{,}05624 * X3(t) - \\ -197{,}038 * X4(t) + u(t) \quad (2)$$

GQ test checks if model is the homoscedastic or heteroschedastic according to the Gauss-Markov theorem's condition. Model is homoschedastic if:

$$\begin{cases} GQ \leq Fcrit \\ 1/GQ \leq Fcrit \end{cases} \quad (3)$$

Table 8. Goldfeld-Quandt test

GQ	0,1046
1/GQ	9,56
Fcrit	5,05

Source: by authors

Fcrit > GQ and < 1/GQ ==> the variance isn't constant in different time periods. Then our model is heteroschedastic. Then we must reestimate our model and should divide data by the variance of the disturbance term.

The test assumes that d lies between 4 and 0, presented in Table 9. The critical value of d at any significance level depends on the number of explanatory variables in the regression equation and the number of observations in the sample. Our estimations show that d critical is 0,927 and it lies between 0 and dl (1.244). It means that there is no information about autocorrelation of residuals.

Table 9. Durbin-Watson test

			d			
		DW	0,9271928			
	d_L	d_U		$4\text{-}d_L$	$4\text{-}d_U$	
0	1,244	1,65	2	2,35	3,756	4
	DW lies between 0 and dL => there is a positive autocorrelation (nearest residuals).					
	So, the third null hypothesis is rejected => $E(\varepsilon_i,\varepsilon_j)\neq 0$					

Source: by authors

Coefficients of the model for Y2 are represented in Table 10.

Table 10. Coefficients of the model for Y2

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-9554,31	6017,447	-1,58777	0,133191	-22380,2	3271,578
X Variable 1	40,04568	32,50332	1,232049	0,236896	-29,2335	109,3249
X Variable 2	-2,03974	0,906172	-2,25094	0,039816	-3,9712	-0,10828
X Variable 3	21,97329	13,1992	1,664745	0,116707	-6,16013	50,10671
X Variable 4	1,149263	0,341636	3,364001	0,004261	0,421084	1,877442

Source: by authors

Tcrit is equal to 2,13145. Absolute values of t Stat of β1 and βn > tcrit, then our coefficients are significant.

$$Y(t) = -9554{,}31 + 40{,}04568 * X1(t) - 2{,}03974 * X2(t) + 21{,}97329 * X3(t) + \\ + 1{,}1492363 * X4(t) + u(t) \quad (4)$$

GQ test checks if model is the homoscedastic or heteroschedastic according to the Gauss-Markov theorem's condition (Table 11). Model is homoschedastic if:

$$\begin{cases} GQ \leq Fcrit \\ 1/GQ \leq Fcrit \end{cases} \quad (5)$$

Table 11. GQ test for Y2 model

GQ	0,00246
1/GQ	406,44
Fcrit	5,05

Source: by authors

Fcrit > GQ and < 1/GQ ==> the variance isn't constant in different time periods. Then our model is heteroschedastic.

The test assumes that d lies between 4 and 0, presented in Table12. The critical value of d at any significance level depends on the number of explanatory variables in the regression equation and the number of observations in the sample. Our estimations show that d critical is 0,927 and it lies between 0 and dl (1.244). It means that there is no information about autocorrelation of residuals.

Table 12. Durbin-Watson test

			d			
		DW	2.52143			
	d_L	d_U		$4-d_L$	$4-d_U$	
0	1,244	1,65	2	2,35	3,756	4
	DW lies between $4-d_L$ and $4-d_U$ => there is a negative autocorrelation.					

Source: by authors

Coefficients of the model for Y are represented in Table 13.

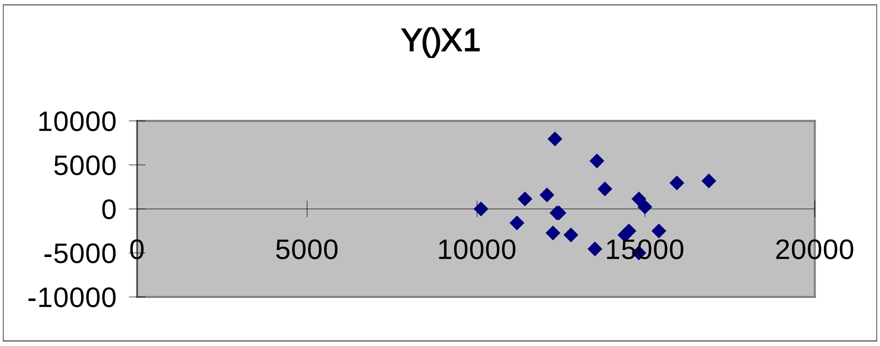
Table 13. Coefficients of the model for Y

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-58360,4	41149,21634	-1,418263545	0,183817	-148929,2	32208,38
X Variable 1	-0,72575	0,948867647	-0,764856924	0,460451	-2,814192	1,362696
X Variable 2	154,74	124,3467772	1,244423452	0,239206	-118,9454	428,4255
X Variable 3	-0,25282	0,169092891	-1,495152499	0,163	-0,624991	0,119351
X Variable 4	9,071495	331,7107118	0,02734761	0,978672	-721,0189	739,1618
X Variable 5	-50,6915	94,98219417	-0,533694641	0,60417	-259,7459	158,3629
X Variable 6	-3,27932	2,921006838	-1,122669033	0,285485	-9,708417	3,149769
X Variable 7	93,05088	47,89247002	1,942912629	0,078054	-12,35973	198,4615
X Variable 8	2,430478	1,896936842	1,28126468	0,226452	-1,744652	6,605608

Source: by authors

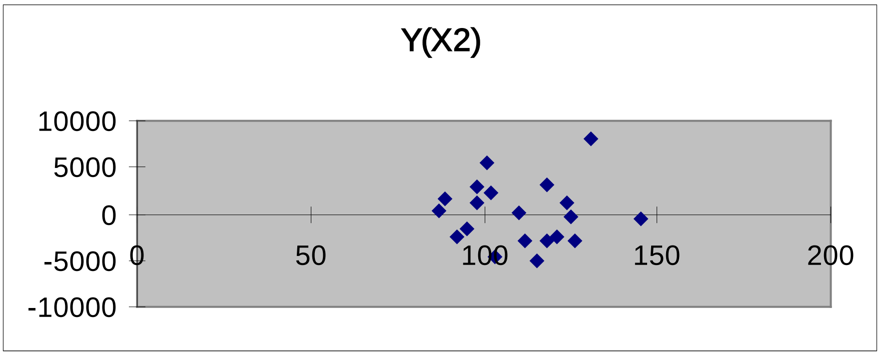
Dispersion charts for X1-X8 variables are submitted in figures 1-8.

Figure 1. Dispersion charts for X1



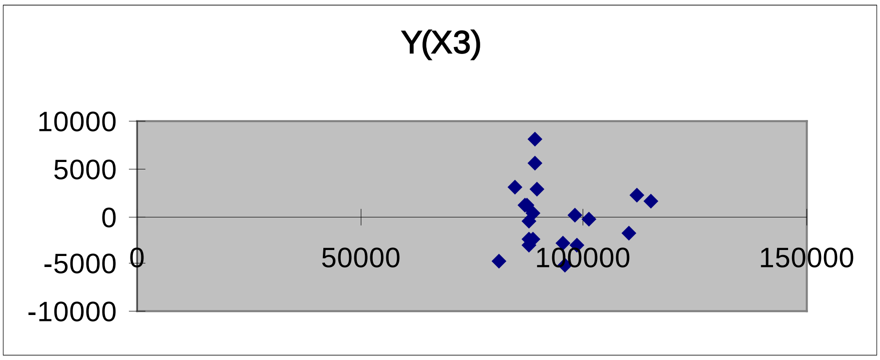
Source: by authors

Figure 2. Dispersion charts for X2



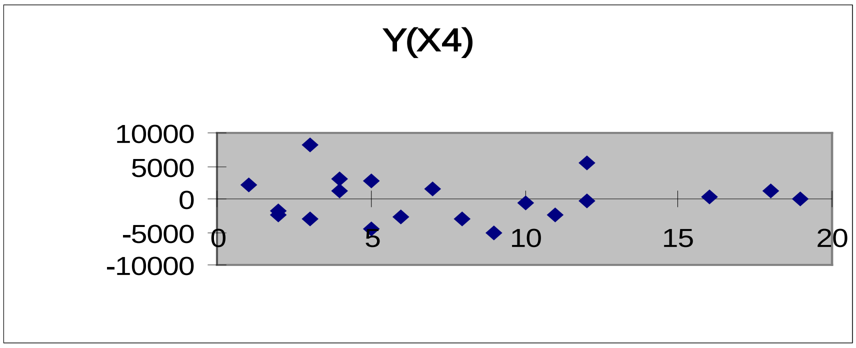
Source: by authors

Figure 3. Dispersion charts for X3



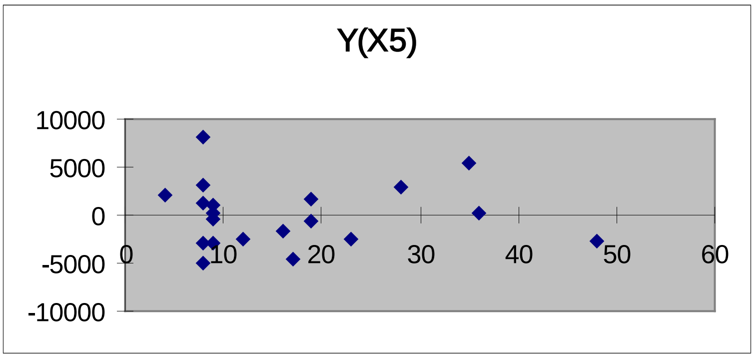
Source: by authors

Figure 4. Dispersion charts for X4



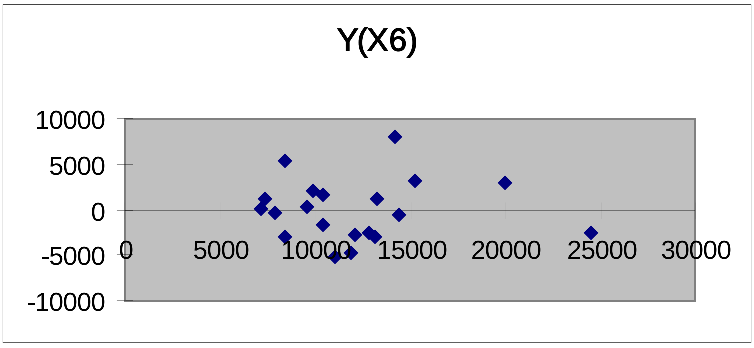
Source: by authors

Figure 5. Dispersion charts for X5



Source: by authors

Figure 6. Dispersion charts for X6



Source: by authors

Figure 7. Dispersion charts for X7

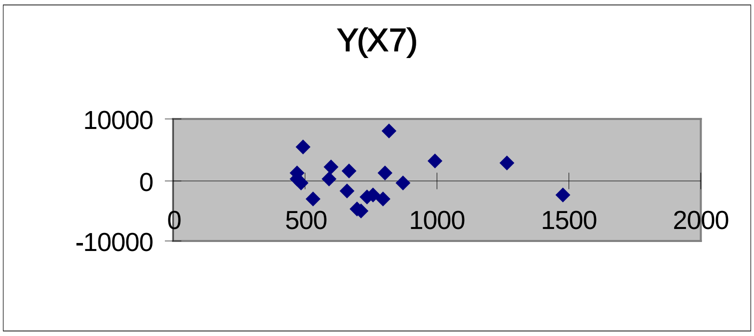


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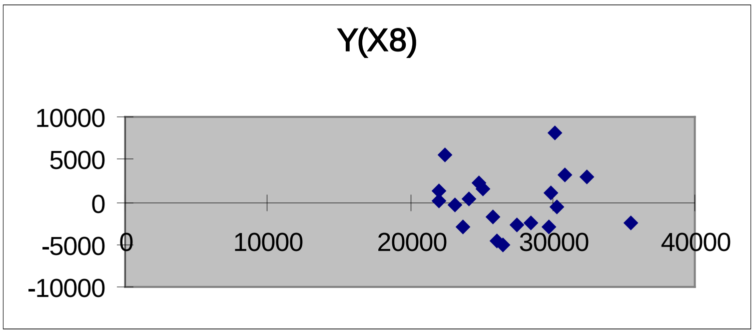
Figure 8. Dispersion charts for X8



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T-Test for Y-model is represented in Table 14.

Table 14. T-Test for Y-model

	Coefficients	Standard Error	t Stat
Intercept	-58360,4	41149,21634	-1,418263545
X Variable 1	-0,72575	0,948867647	-0,764856924
X Variable 2	154,74	124,3467772	1,244423452
X Variable 3	-0,25282	0,169092891	-1,495152499
X Variable 4	9,071495	331,7107118	0,02734761
X Variable 5	-50,6915	94,98219417	-0,533694641
X Variable 6	-3,27932	2,921006838	-1,122669033
X Variable 7	93,05088	47,89247002	1,942912629
X Variable 8	2,430478	1,896936842	1,28126468

Source: by authors

Tcrit is equal to 2,202085. Absolute values of t Stat of $\beta 1$ and βn > tcrit, then our coefficients are significant.

$$Y = - 58360{,}4 - 0{,}72575 * X1 + 154{,}74 * X2 - 0{,}25282 * X3 + 9{,}071495 * X4 - 50{,}6915 * X5 - 3{,}27932 * X6 + 93{,}05088 * X7 + 2{,}430478 * X8 + u(t) \quad (6)$$

5. DISCUSSION

GQ test checks if model is the homoscedastic or heteroschedastic according to the Gauss-Markov theorem's condition, presented in Table 15. Model is homoschedastic if:

$$\begin{cases} GQ \leq Fcrit \\ 1/GQ \leq Fcrit \end{cases} \quad (7)$$

Table 15. Goldfeld-Quandt test

GQ	0,095587
1/GQ	10,46
Fcrit	3,79

Source: Beck & Levine, 2004

Fcrit > GQ and < 1/GQ ==> the variance isn't constant in different time periods. Then our model is heteroschedastic.

The Durbin—Watson test is based on a simple idea: if the correlation of regression errors is not zero, then it is also present in the regression residualse (resulting from the application of the usual least squares method. The Durbin—Watson test uses statistics of the form to assess correlation. Simple calculations allow us to verify that the Durbin—Watson statistics are related to the sample correlation coefficient between neighboring observations in the following way (Table 16).

Table 16. Durbin-Watson test

			d			
		DW	0,46371			
	dL	dU		4-dL	4-dU	
0	1,244	1,65	2	2,35	3,756	4
	DW lies between 0 and dL => there is a positive autocorrelation (nearest residuals).					
	So, the third null hypothesis is rejected => E(εi,εj)≠0					

Source: by authors

The test assumes that d lies between 4 and 0. The critical value of d at any significance level depends on the number of explanatory variables in the regression equation and the number of observations in the sample. Our estimations show that d critical is 0,927 and it lies between 0 and dl (1.244). It means that there is no information about autocorrelation of residuals.

6. CONCLUSION

In this work the model of GDP function to the economy of Kazakhstan is represented. The coefficients of the model for forecasting the level and future changes of GDP of the country are estimated. As the variables having impact on a resultant factor, the following variables act: size of the market of the capital, billion tenge, Y1; size of the market of securities, billion tenge, Y2.

These variables depend on the other variables. Thus, size of the market of the capital (Y1) depends on the following variables tested in the model:

- number of operations on issue of securities;
- the volume of operations on issue of securities;
- number of operations of nonresidents with actions at the secondary auction of the KASE;
- rates of change of actions of leading issuers at the KASE.

Size of the market of securities (Y2) depends on the following variables:

- primary placement at the KASE;
- Volume of the credit market, billion tenge;
- Volume of the insurance market, billion tenge;

As the result we got model of this general form:

$$Y = -58360{,}4 - 0{,}72575 * X1 + 154{,}74 * X2 - 0{,}25282 * X3 + 9{,}071495 * X4$$
$$- 50{,}6915 * X5 - 3{,}27932 * X6 + 93{,}05088 * X7 + 2{,}430478 * X8 + u(t)$$

The model is good for application in case of adequacy, then it is possible and reasonable to use it for forecasting.

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Serial number of components	The actual characteristic values of PCA	Values obtained by parallel analysis	Decision
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2	1,913	1.4326	Accept
3	1,107	1.3287	Reject
4	0,967	1.2433	Reject

Source: Author's calculation

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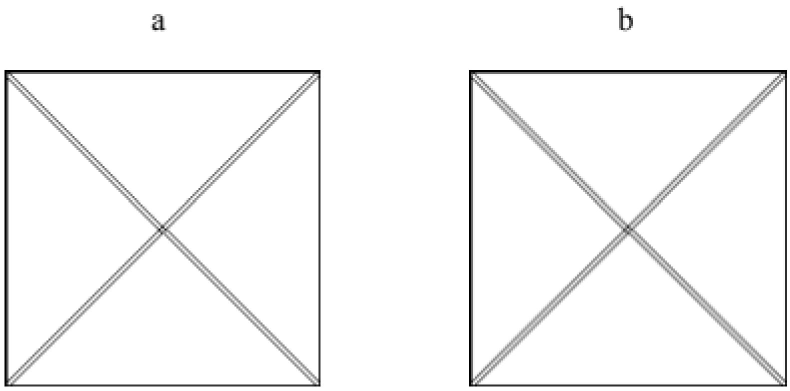

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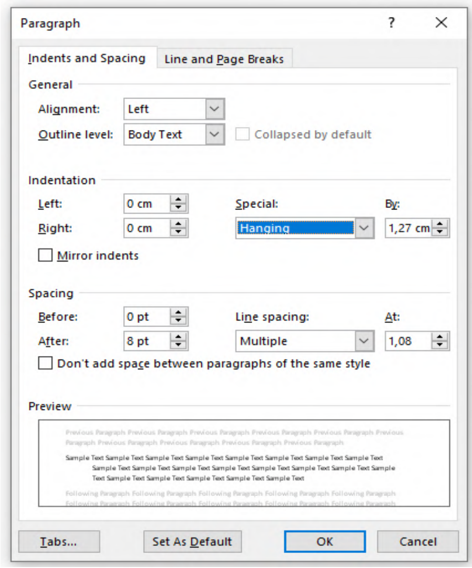

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