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FACTOR ANALYSIS OF THE TOURISM SECTOR IN THE ADRIATIC-IONIAN INITIATIVE COUNTRIES

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ABSTRACT

Tourism represents a key segment of economic development in the countries of the Adriatic-Ionian Initiative (AII), contributing to the gross domestic product (GDP) and influencing employment, investments, and the trade balance of the region. This analysis examines the trends of tourism creation and diversion in eight AII countries-Albania, Bosnia and Herzegovina, Croatia, Greece, Italy, Montenegro, Serbia and Slovenia-over the period from 1995 to 2024.

This paper employs a multivariate approach to identify key factors that shape the competitiveness of destinations and contribute to the stability of the tourism sector. The study considers the impact of infrastructure investments, political stability, macroeconomic indicators, government policies on tourism subsidies, as well as the effects of pandemics and global economic crises on tourism flows.

The results indicate that Croatia, Greece and Montenegro are the leaders in the tourism industry, with tourism accounting for more than 10% of GDP. Albania and Slovenia show stable growth, whereas Italy, despite being an economic powerhouse, has a lower tourism share compared to its industrial and technological sectors. Bosnia and Herzegovina and Serbia face challenges in attracting foreign tourists due to infrastructural constraints and insufficient promotion.

The study's conclusions emphasise the importance of sustainable tourism development strategies, increased investments and regional cooperation to mitigate the effects of seasonality and enhance the sector's resilience to global economic changes.

1. INTRODUCTION

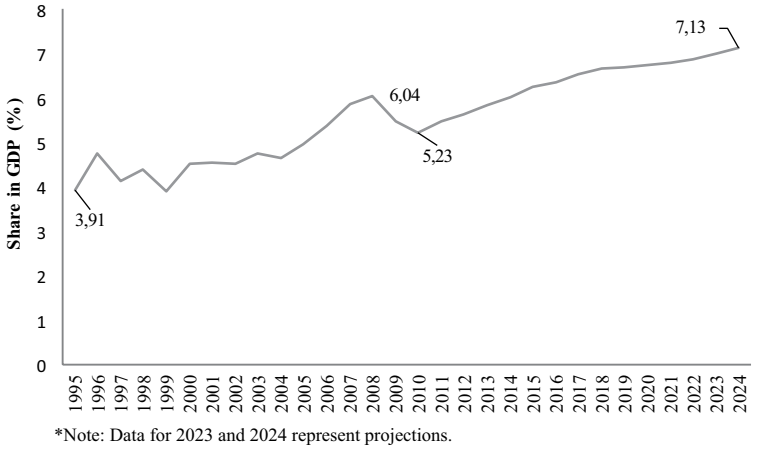
Tourism in the Adriatic-Ionian Initiative region represents one of the key segments of economic development, but its importance and contribution to the economy vary among countries (Ritchie & Crouch, 2003). While some countries, such as Croatia and Montenegro, heavily rely on revenue generated through tourism. Others, such as Serbia and Bosnia and Herzegovina, view tourism as an addition to overall economic activity.

The development of tourism in the region is shaped by various factors, including natural and cultural resources, investments in infrastructure, tourism support policies, as well as global trends and economic crises (Gössling et al, 2020; Blake & Sinclair, 2003). Historically, tourism in the region has grown gradually, with occasional fluctuations caused by economic crises, pandemics and changes in the political landscape (Hall & Williams, 2008; Sharpley & Telfer, 2014; Papatheodorou, 2004).

Given the different economic models and priorities of each country, the level of tourism's share in GDP varies significantly (Earl & Hall, 2021; Page & Connell, 2020). Albania, Montenegro and Croatia record high tourism growth rates, whereas Italy, despite being economically strong, has a diversified economic structure in which tourism is not the dominant sector (UNWTO, 2025; WTTC, 2023). On the other hand, Serbia and Bosnia and Herzegovina face challenges in attracting international tourists due to a lack of investment in promotion and infrastructure capacity.

Through an analysis of tourism trends in the region over the past thirty years, this paper examines the economic and political factors shaping the tourism industry and provides recommendations for its further stabilisation and growth (World Bank, 2022; OECD, 2024). The key research objectives include identifying the main drivers of tourism growth, assessing the factors contributing to the creation and diversion of tourism flows, and defining strategies for enhancing the region's competitiveness in the global tourism market.

The graph illustrates the movement of tourism's share in the gross domestic product (GDP) of the AII countries over the period from 1995 to 2024, analysing trends, year-on-year fluctuations and long-term projections (UNWTO, 2025; WTTC, 2023). The data show significant differences depending on the country and period, with some countries recording stable tourism growth, while others have experienced more pronounced oscillations. Descriptive statistics indicate variations in the average share of tourism in GDP, with the standard deviation reflecting the sector's volatility.



*Note: Data for 2023 and 2024 represent projections.

Figure 1. Share of the Tourism Sector in AII Countries, 1995-2024*
Source: UNWTO, 2025; WTTC, 2023

In Albania, the share of tourism in GDP increased from 3.56% in 1995 to 8.61% in 2024. Significant growth has been recorded since 2010, indicating increased investments in tourism and the development of tourism infrastructure. Given Albania's smaller overall economic strength, tourism plays a crucial role in its growth and development.

Bosnia and Herzegovina experienced slow growth, from an initial 1.09% in 1995 to 3.04% in 2024. Stabilisation and mild growth in recent years suggest the potential for sector development, but also highlight challenges in attracting investments due to slower economic growth and structural issues.

In Croatia, where tourism is a key economic sector, the share grew from 7.48% in 1995 to 12.64% in 2024, with continuous growth and only short-term declines during global economic crises. As a country whose economy significantly depends on tourism, Croatia invests in infrastructure projects and destination promotion to maintain its leading position in the region.

Greece has maintained a relatively stable share of tourism in GDP, ranging from 4.75% in 1995 to 8.62% in 2024. Although the pandemic caused a decline, the sector quickly recovered and continued to grow. Greece, as a more developed economy, uses tourism as an important part of its economy but also relies on other sectors, contributing to its resilience.

Italy has maintained a stable tourism share in GDP between 4.34% and 5.79%, with a slight increase in recent years. As one of the world's leading economies,

Italy does not rely solely on tourism, but rather uses it as an additional economic driver, alongside a strong industrial and technological sector.

Montenegro has experienced a sharp rise in tourism since 2000, increasing from 2.15% to over 12% in 2024, demonstrating sector expansion in recent decades. Given its less developed economy, tourism has become a key factor in economic growth and development.

Table 1. Share of Tourism in GDP (1995-2024), AII Countries

Year	Albania	BiH	Croatia	Greece	Italy	Montenegro	Serbia	Slovenia
1995	3.56	1.09	7.48	4.75	4.34	4.12	1.28	4.66
1996	2.81	0.93	9.54	4.33	4.55	10.71	0.54	4.68
1997	3.20	0.62	6.34	3.77	4.65	9.29	0.54	4.53
1998	2.99	2.64	6.89	4.18	4.78	8.77	0.81	4.12
1999	4.31	2.33	6.77	5.35	4.87	3.32	0.75	3.54
2000	5.70	2.15	6.71	6.17	5.31	4.10	2.07	3.93
2001	5.77	2.28	7.59	6.15	5.14	4.48	1.16	3.86
2002	6.47	2.66	7.24	6.06	4.78	4.54	0.86	3.61
2003	5.72	2.66	10.23	5.54	4.48	5.19	0.89	3.31
2004	5.54	2.79	9.44	5.56	4.46	5.23	0.92	3.26
2005	6.30	2.90	9.71	5.80	4.30	6.35	1.04	3.30
2006	6.86	2.98	9.62	5.59	4.33	9.21	1.01	3.27
2007	7.72	2.96	9.59	5.38	4.24	12.29	1.66	3.14
2008	7.60	2.80	10.05	5.46	4.00	13.43	1.77	3.18
2009	8.35	2.65	9.16	5.62	3.86	9.10	1.79	3.32
2010	7.71	2.42	8.39	5.47	3.85	8.87	1.79	3.30
2011	7.52	2.40	9.12	5.96	4.27	9.23	1.83	3.37
2012	8.19	2.16	8.80	6.08	4.52	9.96	1.91	3.37
2013	7.64	2.25	9.44	6.98	4.81	10.30	1.90	3.42
2014	8.13	2.22	9.81	7.45	5.05	10.17	2.03	3.34
2015	8.05	2.37	10.13	7.74	5.32	10.91	2.24	3.30
2016	8.55	2.55	10.44	7.60	5.37	10.72	2.35	3.29
2017	8.47	2.61	10.93	8.05	5.49	11.01	2.33	3.29
2018	8.49	2.67	11.00	8.28	5.51	11.67	2.32	3.38
2019	8.46	2.73	11.28	8.23	5.53	11.60	2.36	3.37
2020	8.44	2.80	11.55	8.31	5.55	11.43	2.39	3.44
2021	8.46	2.86	11.73	8.39	5.59	11.43	2.45	3.49
2022	8.46	2.91	11.97	8.45	5.65	11.54	2.50	3.54
2023*	8.53	2.97	12.30	8.53	5.72	11.82	2.56	3.59
2024*	8.61	3.04	12.64	8.62	5.79	12.04	2.63	3.64

*Note: Data for 2023 and 2024 represent projections.

Source: UNWTO, 2025; WTTC, 2023

Serbia had a lower initial share of tourism in GDP, but in the last decade, the sector has grown significantly, reaching approximately 5.5% in 2024. Although Serbia's economy relies on industry and agriculture, the growth of tourism reflects its increasing role in economic diversification.

Overall, the average share of tourism in GDP in the region has significantly increased, reaching 8% in 2024. Projections indicate continued growth, driven by investments, tourism promotion and post-pandemic recovery. The Adriatic-Ionian Initiative countries are seeing an increasing importance of tourism in GDP, with Croatia, Montenegro and Greece emerging as regional leaders. Further growth will depend on market stability, infrastructure investments, and the sustainability of tourism offerings, while each country's economic strength will shape its tourism development capacity.

The importance of tourism to the overall economy can be analysed through the indicator of total tourism contribution (Dwyer, 2022; Gladstone, & Fainstein, 2001). The total contribution of tourism consists of three main components, as shown in the following table (Hall, 2024).

Table 2. Structure of Tourism Contribution to the Economy

Name	Description
Direct Contribution of Tourism	Revenue directly related to the tourism sector: hotels and accommodation capacities, restaurants and hospitality services, transport and travel agencies, airlines and other means of transport in tourism
Indirect Contribution of Tourism	Activities related to tourism but not forming the core of the tourism industry: supply, food and beverages for hotels, government tax revenues from tourism, investment in marketing and tourism promotion, government incentives and sector support
Induced Contribution of Tourism	Spending by employees in the tourism sector: salaries of hotel employees, housekeeping and tourism, household consumption dependent on the tourism industry, multiplier effects on other economic sectors.

2. MATERIALS AND METHODS

Principal Component Analysis (PCA) is a statistical technique used for reducing the dimensionality of large datasets (Abdi & Williams, 2010). This method allows the transformation of a set of highly correlated variables into a new set of mutually uncorrelated variables, known as principal components. PCA is widely applied in the fields of machine learning, statistics, economics, biology and other scientific disciplines focused on data analysis. By using PCA, complex data can be simplified while retaining the maximum amount of information, which facilitates interpretation and visualisation (Jolliffe, 2002). This technique

includes several iterations, which will be explained in the following text (Günter et al, 2007).

Data Normalisation. Before applying PCA, data are often standardised to avoid the dominance of variables with larger scales. Standardisation is performed using the formula:

$$Z_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j} \quad \text{.....(1)}$$

Where:

a) x_{ij} - value of the j-th variable for the i-th sample,
b) $\bar{x}_j$ - mean value of the j-th variable,
c) s_j - standard deviation of the j-th variable.

Calculation of the Covariance Matrix

For standardised data, the covariance matrix is calculated as follows:

$$C = \frac{1}{n-1} X^T X \quad \text{.....(2)}$$

Where:

a) X - data matrix of dimensions n×p (n samples, p variables),
b) C - covariance matrix of dimensions p×p.

Eigenvalue and Eigenvector Calculation. A key part of PCA is finding the eigenvalues and eigenvectors of the covariance matrix.

a) Eigenvalues λ_j measure variance along the new axis.

b) Eigenvectors v_j define the directions of the new coordinate systems:

$$Cv_j = \lambda_j v_j \quad \text{.....(3)}$$

Eigenvalues are sorted from highest to lowest, with the first components carrying the most information about the data.

Projection of Data onto New Axes

Once the eigenvectors are found, the original data are projected onto new axes. The data are transformed into a new space using the eigenvector matrix:

$$Z = XV \quad \text{.....(4)}$$

Where:

- Z - Transformed data matrix expressed in principal component coordinates.

This step enables dimensionality reduction while retaining only the first few components that carry the highest variance.

Interpretation of PCA

- Variance of Principal Components – The total percentage of variance explained by the first k components is calculated as follows:

$$\text{Percentage of variance} = \frac{\sum_{i=1}^{k} \lambda_i}{\sum_{i=1}^{p} \lambda_i} \times 100\% \quad \text{.....(5)}$$

This procedure helps in selecting the number of components to retain. Typically, the minimum number of components explaining a high percentage of variance (e.g., 85-95%) is chosen.

- Interpretation of Principal Components – The coefficients in eigenvectors ($\mathbf{v}_i$) provide information on the influence of each original variable on the principal components. High absolute values suggest a strong relationship between original variables and principal components.

Application of PCA

- Dimensionality reduction – Retaining only principal components that explain the highest variance.
- Data visualisation – Projecting data into 2D or 3D space for better analysis of data structure.
- Decorrelation of data – Originally correlated variables are transformed into a mutually uncorrelated set of variables.
- Preprocessing data for regression and classification models – PCA can improve the efficiency of machine learning models.

PCA is a powerful technique for analysing large and complex datasets. It reduces dimensionality while preserving essential information, making it easier to interpret and analyse data. By leveraging linear algebra and eigenvalues, PCA identifies the most significant patterns in the data. In comparison, Factor Analysis (FA) is another dimensionality reduction technique, but it focuses on modeling the underlying relationships between observed variables and latent factors.

PCA aims to maximise the variance captured in the data by transforming it into a set of orthogonal (uncorrelated) components. It uses eigenvalues and eigenvectors to identify principal components, which are linear combinations of the original variables. PCA does not assume any underlying structure in the data. The principal components are ordered by the amount of variance they explain, making it easier to identify the most important patterns. PCA is widely used in fields like image processing, finance and neuroscience for tasks such as noise reduction, data visualisation and feature extraction.

FA aims to identify latent factors that explain the correlations among observed variables. It models the data as a combination of common factors and unique variances, using techniques like maximum likelihood estimation. FA assumes that the observed variables are influenced by a smaller number of unobserved latent factors. The factors are interpreted based on their loadings which represent the strength of the relationship between observed variables and latent factors. FA is commonly used in psychology, social sciences and market research to identify underlying constructs, validate questionnaires and explore data structures.

While PCA components are orthogonal and independent, FA factors can be correlated. PCA focuses on capturing maximum variance, whereas FA focuses on explaining covariances among variables. PCA is often used for data compression and visualisation, while FA is used for identifying underlying constructs and validating measurement models. Both techniques are valuable for dimensionality reduction, but the choice between PCA and FA depends on the specific goals and assumptions of the analysis.

The following table presents explanations of tourism sector indicators, which will serve as the basis for PCA analysis in the AII region countries.

The original data used in this analysis were retrieved from reputable international databases, primarily UNWTO and WTTC. However, due to occasional gaps in time series and differing reporting standards, certain preprocessing steps were necessary. First, the dataset was reviewed for missing values, which were addressed through linear interpolation for intermediate years and forward-filling for recent gaps. Secondly, all variables were standardised using z-score normalisation to ensure comparability and avoid dominance of variables measured on larger scales.

Table 3. Selection and Explanation of Variables

O. nr	Variable Name	Model abbreviation	Explanation
1.	Capital Investment in Tourism (CIT)	CIT	Total value of investments directed towards the development of tourism infrastructure and facilities. This includes investments in hotels, accommodation, economic and service infrastructure, recreational parks and other key facilities in the tourism industry. Capital investment is crucial for long-term sustainability and competitiveness of the tourism sector and the national economy.
2.	Visitor Export (Foreign Expenditure) (VEFE)	VEFE	Revenues that the domestic economy generates from foreign tourists. This includes all spending made by foreign tourists in a country, including accommodation, shopping and services. This indicator measures the impact of tourism on the national economy.
3.	Business Tourism Spending (BTS)	BTS	Total business travel expenses in the country. This includes costs related to conferences, seminars, business meetings and travel for corporate purposes. This indicator shows the level of attractiveness of a destination for business tourism.
4.	Direct Contribution of Travel & Tourism (DCTT)	DCTT	Direct contribution of hotels, restaurants, transport and related businesses to the tourism industry. This includes revenue generated directly from tourism-related services. This indicator measures the direct GDP impact of tourism, excluding indirect effects.
5.	Domestic Tourism Spending (DTS)	DTS	Spending by domestic residents on tourism-related travel within their own country. This includes accommodation, transport and leisure activities. This indicator assesses the strength of domestic tourism demand.
6.	Government Tourism Spending (GTS)	GTS	Public expenditures directed toward tourism development and promotion. This includes funding for tourism campaigns, subsidies for tourism businesses and investment in local and national tourism infrastructure.
7.	Internal Travel & Tourism Contribution (ITTC)	ITTC	Total revenue generated from domestic and international tourism. This indicator includes both direct and indirect contributions of tourism to GDP, reflecting the broader economic impact of the sector.
8.	Leisure Travel & Tourism Spending (LTTS)	LTTS	Total spending on leisure tourism, including domestic and international travelers. This indicator measures tourism demand for leisure activities such as vacations, cultural visits and recreational travel.
9.	Outbound Travel & Tourism Expenditure (OTTE)	OTTE	Spending by residents of a country on travel and tourism abroad. This indicator reflects the economic impact of outbound tourism and measures the purchasing power of residents for travel and tourism services.
10.	Travel Total Tourism Contribution (TTTC)	TTTC	Indicator that measures the total economic impact of tourism on the national economy. This variable is key to assessing tourism's contribution to overall economic performance.

Source: UNWTO, 2025; WTTC, 2023

To assess the adequacy of the dataset for Principal Component Analysis, two standard diagnostics were applied. The **Kaiser-Meyer-Olkin (KMO) measure** of sampling adequacy reached a value of **0.814**, which indicates a very good degree of common variance and supports the use of PCA. Furthermore, **Bartlett's test of sphericity** was statistically significant ($\chi^2 = 12004.689$, $df = 45$, $p < 0.001$), confirming that the correlation matrix is not an identity matrix and that sufficient intercorrelation exists among variables.

The **correlation matrix** revealed very high pairwise correlations among most indicators, with the majority of coefficients exceeding **0.90** and all significant at the **0.001 level**. This suggests strong multicollinearity, which justifies dimensionality reduction via PCA. However, the **determinant of the correlation matrix was extremely low (6.29×10^{-23})**, indicating near-singularity and suggesting a high level of redundancy among variables. This explains the empirical result where the first principal component captures over **99.7%** of the total variance in the dataset.

Although both Factor Analysis (FA) and PCA are widely used for multivariate data exploration, PCA was chosen for this study due to its focus on maximising explained variance rather than modeling latent constructs. Given the objective of reducing multicollinearity and simplifying the complex structure of interrelated tourism indicators across countries, PCA provides a more straightforward and interpretable framework. Unlike FA, PCA does not assume an underlying factor model or error terms, which aligns well with the exploratory nature of this research.

To contextualise the factor structure, descriptive statistics for all variables were computed prior to analysis. These include means, standard deviations and pairwise correlations. This step supported the interpretation of principal components and provided insight into the variability and distribution of each indicator across the observed time period and countries.

3. RESULTS

The following section presents the results of the Principal Component Analysis (PCA) through tables, based on which discussions can be made, appropriate conclusions can be drawn, and recommendations for further development policies in the tourism sector, as well as projections for further research, can be given. The authors used the SPSS software package, version 25, for the analyses.

The variables TTTC and ITTC, with their substantial covariance values of 5747.392 and 3221.785 respectively, underscore their pivotal role in contributing to the total variance within the dataset. These pronounced covariance figures

indicate that these variables are paramount in elucidating the overall variability, thereby making them indispensable for comprehending the underlying patterns inherent in the data.

A fundamental component of Principal Component Analysis (PCA) is the computation of eigenvalues and eigenvectors derived from the covariance matrix. Eigenvalues quantify the variance encapsulated along each newly defined axis, while eigenvectors delineate the orientations of these axes within the transformed coordinate framework. The eigenvalues are instrumental in pinpointing the principal components that encapsulate the maximum variance, thus facilitating dimensionality reduction while preserving critical information.

In light of these findings, the elevated covariance values associated with TTTC and ITTC accentuate their significance within the dataset. This suggests that any developmental policies or subsequent research endeavors within the tourism sector should prioritise these variables. The insights gleaned from PCA can serve as a strategic compass for policymakers, enabling them to concentrate on key areas that drive variability in tourism data. This targeted focus can lead to more nuanced and effective strategies.

Covariance Matrix. The covariance matrix presents the overall variability of the data among the variables. In this case, the determinant of the matrix amounts to 52.902, indicating the presence of multicollinearity among the variables.

It is particularly important to note that variables such as TTTC and ITTC have high covariance values (5747.392 and 3221.785), which means that they dominate in explaining the total variance in the data. A key part of PCA is finding the eigenvalues and eigenvectors of the covariance matrix. Eigenvalues measure variance along the new axis, while eigenvectors define the directions of the new coordinate system.

The table 'Total Variance Explained' elucidates the contribution of each principal component to the overall variability of the dataset. Remarkably, the first principal component accounts for an overwhelming 99.69% of the total variance. This indicates that nearly all the information within the dataset is encapsulated within a single dimension, underscoring the dominance of this component in capturing the essence of the data.

Such a high percentage of explained variance by the first component suggests that the dataset is highly structured, with most of the variability being driven by a single underlying factor. This simplification is advantageous as it allows for a significant reduction in dimensionality without substantial loss of information, facilitating more efficient data analysis and interpretation.

Table 4. Communalities and covariance matrix

	Initial	Extraction
BTS	137.72	137.72
CIT	20.98	20.98
DTS	1875.88	1875.88
GTS	.24	.24
ITTC	3221.78	3221.78
LTTS	2038.44	2038.44
OTTE	87.73	87.73
TTTC	5747.39	5747.39
DCTT	956.89	956.89
VEFE	199.72	199.72

*Extraction Method: Principal Component Analysis

Source: Author's own calculations in SPSS 25

In scientific terms, the ability of the first component to capture almost the entirety of the variance implies that subsequent components contribute minimally to the overall variability. This highlights the effectiveness of PCA in distilling complex datasets into their most informative elements, thereby streamlining the analytical process.

Explained Variance and Number of Components. The table 'Total Variance Explained' shows how much each component contributes to the total variability of the data. The first component accounts for 99.69% of the total variance, meaning that practically all the information is contained within a single dimension.

This suggests that it would be sufficient to use only one component to summarise the data, as the remaining components contribute negligibly to the total variability.

Table 5. Total Variance Explained

Component	Initial Eigenvalues[a]			Extraction Sums of Squared Loadings	
	Total	% of Variance	Cumulative %	Total	% of Variance
1	14243	99.69	99.69	14243	99.69
2	30.79	.22	99.91	30.79	.22
3	9.76	.068	99.98	9.76	.068
4	1.16	.008	99.99	1.16	.008
5	.79	.006	99.99	.79	.006
6	.74	.005	99.99	.74	.005
7	.35	.002	99.99	.35	.002
8	.13	.001	100.00	.13	.001

Source: Author's own calculations in SPSS 25.

The factor loading matrix reveals the strength of the relationship between each original variable and the newly derived components. Notably, all variables demonstrate high loadings on the first component, exceeding 0.9. This confirms that the first component is the primary factor in explaining tourism data. Such high loadings suggest that the dominant dimension in the dataset is closely linked to the overall economic significance of tourism. The factor loadings underscore the importance of the first component in capturing the essence of the data. The strong association between the original variables and this component indicates that the economic impact of tourism is a central theme driving the variability in the dataset. This insight is crucial for understanding the key factors influencing tourism and can guide policymakers in developing strategies that focus on the economic aspects of tourism.

The high loadings on the first component also highlight the effectiveness of PCA in identifying the most informative dimensions of the data.

Factor Loading Matrix. The factor loadings indicate how strongly each original variable is related to the new components. All variables exhibit high loadings on the first component (above 0.9), confirming that it is the key factor in explaining tourism. This suggests that the dominant dimension in the data is associated with the overall economic significance of tourism.

Table 6. Factor Loading Matrix

Indicators	Component			
	1	2	3	4
BTS	.993	-.097	.038	.038
CIT	.923	.207	.304	-.028
DTS	.997	-.080	-.012	-.002
GTS	.923	-.112	.086	.151
ITTC	1.000	.005	-.014	.003
LTTS	.999	.022	-.035	-.005
OTTE	.992	-.038	.062	.085
TTTC	1.000	.008	.025	-.004
DCTT	1.000	-.001	-.014	.009
VEFE	.961	.273	-.032	.018

*Extraction Method: Principal Component Analysis. a. Four components extracted.

Source: Author's own calculations in SPSS 25.

The rotation of principal components (Varimax rotation) enables a better interpretation of factor structures. The results are presented in the following table and through this rotation, several key factors have been identified:

a) Factor 1 (Economic Contribution of Tourism)
This factor includes high loadings for BTS (Business Tourism Spending), DTS (Domestic Tourism Spending) and ITTC (Internal Travel & Tourism Contribution). This indicates that tourism is predominantly linked to the economic performance of the countries.

b) Factor 2 (Investments and Government Support). CIT (Capital Investment in Tourism) and GTS (Government Tourism Spending) show strong influence on this factor. This suggests that investments and government support are key elements in sustaining tourism.

c) Factor 3 (Tourism Flows). The variables VEFE (Visitor Export - Foreign Expenditure) and OTTE (Outbound Travel & Tourism Expenditure) are more pronounced in this factor. This highlights the importance of foreign exchange earnings and tourism flows for the region.

Table 7. Rotated Factor Loading Matrix

	Rescaled Component									
	1	2	3	4	5	6	7	8	9	10
BTS	.704	.465	.516	.135	.008	-.053	-.001	.000	.000	.000
CIT	.440	.788	.408	.134	.005	.000	.000	.000	.000	.000
DTS	.717	.453	.501	.170	-.003	.015	-.004	-.003	.000	-.003
GTS	.461	.391	.777	.177	-.001	.003	.000	.000	.000	.000
ITTC	.689	.499	.472	.230	.001	.013	-.004	-.006	.009	.001
LTTS	.689	.493	.464	.255	-.002	.022	-.006	.001	-.007	.004
OTTE	.649	.503	.536	.172	.095	-.002	.000	.000	.000	.000
TTTC	.674	.522	.478	.210	.002	.008	.001	.015	-.001	.000
DCTT	.687	.491	.483	.232	-.004	.006	.018	.001	.000	.000
VEFE	.572	.607	.360	.418	.011	-.005	.000	.000	.000	.000

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation. a. Rotation converged in 11 iterations

Source: Author's own calculations in SPSS 25.

Hence, the Varimax rotation of principal components has facilitated a clearer interpretation of the factor structures, revealing several key dimensions within the tourism data. Factor 1, labeled as the Economic Contribution of Tourism, encompasses high loadings for BTS, DTS and ITTC, underscoring the strong link between tourism and the economic performance of countries. Factor 2, identified as Investments and Government Support, is characterised by significant loadings for CIT and GTS, highlighting the critical role of investments and governmental support in sustaining the tourism sector. Lastly, Factor 3, termed Tourism Flows,

includes pronounced loadings for VEFE and OTTE, emphasising the importance of foreign exchange earnings and tourism flows for the region. These insights collectively underscore the multifaceted nature of tourism, driven by economic contributions, investment and support, and international tourism dynamics, providing a comprehensive framework for policy development and strategic planning in the tourism sector.

Dominance of the First Component. The first component is so dominant that, in practice, it can replace all variables, demonstrating that tourism in the region primarily depends on its economic contribution. Next, the PCA analysis results will be compared with the data on the share of tourism in GDP across AII countries, leading to certain conclusions.

Table 8. Heatmap of Factor Loadings

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8	PC 9	PC 10
BTS	.993	-.097	.038	.038	0	.049	.003	-.001	-.001	0
CIT	.923	.207	.304	-.028	.012	-.003	.001	.001	.001	0
DTS	.997	-.080	-.012	-.002	.019	-.015	.005	.001	.001	.003
GTS	.923	-.112	.086	.151	.011	.011	.001	.001	0	0
ITTC	1.000	.005	-.014	.003	.011	.008	.008	.005	.002	0
LTTS	.999	.022	-.035	-.005	.014	-.018	.005	-.005	-.006	-.002
OTTE	.992	-.038	.062	.085	-.08	-.012	-.001	-.001	-.001	0
TTTC	1.000	.008	.025	-.004	-.002	.008	.005	-.005	.002	0
DCTT	1.000	-.001	-.014	.009	.015	-.015	-.002	-.016	.007	.002
VEFE	.961	.273	-.032	.018	-.014	.017	.002	0	0	.001

* Dark grey shading indicates high positive loadings, meaning that the variable strongly contributes to a specific component. Underlined values indicate negative loadings, meaning that the variable has an opposite effect in relation to the component. Light grey cells denote a weaker or borderline association with the component, while white cells indicate a negligible or minimal relationship.

The factor analysis generated through the heatmap of factor loadings provides insight into the data structure and the way individual variables contribute to different factors. This matrix allows us to understand how key tourism variables relate to the principal components, i.e., the latent dimensions that shape tourism in the analysed countries.

At first glance, it becomes clear that the first component is dominant in the analysis. Almost all variables have high factor loadings in relation to it, which means that tourism, as a sector, exhibits a high degree of homogeneity among the variables. In other words, internal and direct tourism contributions, capital investments, domestic and foreign tourism expenditures, as well as government support, collectively form a strong dimension that can be interpreted as overall

tourism activity and its economic significance. This component essentially integrates all the main factors that shape tourism and indicates that countries with high values in this component are largely dependent on tourism as an economic sector.

It is interesting to observe the role of the second and third component, which isolate certain aspects of tourism that are not as present in the first dimension. The second component shows significant correlation with capital investments in tourism, suggesting that some countries do not rely solely on natural resources and existing attractions but instead heavily invest in tourism development. This component may represent the difference between countries that actively invest in developing tourism infrastructure, hotels and transport networks and those that depend on already established capacities. The third component further enriches this picture by including government support and foreign tourism expenditures, indicating countries where the government actively subsidises tourism or where the sector largely depends on incoming foreign tourists.

Further examination of the remaining components reveals that a significant portion of the data variance is explained by the first three or four factors, while the remaining components do not show strong associations with key variables. These less pronounced components may indicate specific, less significant patterns of variability in the data that are not dominant in the overall tourism picture but may be useful for understanding minor nuances among countries or individual aspects of tourism that do not affect the entire industry to the same extent.

4. DISCUSSIONS

The analysis suggests that tourism is a highly integrated sector, where economic factors, investments, and tourism expenditures move together, creating a strong development dimension (Hall, 2024). However, it is also evident that there are countries investing in tourism in different ways while some rely on natural resources and existing attractions, others invest significant funds in infrastructure and marketing to attract tourists (Hall, 2024). This means that, although tourism may appear as a homogeneous industry at first glance, in reality, it is shaped by different factors that are key to understanding the specific differences between countries (Dwyer, 2022).

The conclusion that can be drawn from this analysis is that overall tourism activity is the most important dimension that distinguishes countries, but there are also additional nuances that set some countries apart depending on whether

they rely more on private investments, government support or international tourism expenditures (Gladstone, & Fainstein, 2001). This type of analysis can help in formulating policies for the future development of tourism, as it clearly demonstrates which countries already have a stable tourism economy and which could benefit from additional investments or strategies to attract tourists.

The analysis of tourism's share in GDP in the AII region provides a clear economic context for understanding the results obtained through factor analysis and the heatmap of factor loadings. In both datasets, it is evident that tourism does not function in the same way in every country. While in some states it is a key pillar of the economy, in others, it remains a secondary economic activity.

One of the most important insights derived from this analysis is the stability of tourism in different economies over time. In some countries (such as Croatia and Montenegro), tourism has been and remains one of the fundamental pillars of the economy, while in others (such as Italy and Greece), it has maintained moderate growth without fundamental changes. Countries such as Serbia and Bosnia and Herzegovina show slight growth in tourism, but not in a way that would lead to major changes in their economic structures.

These trends are clearly recognised in the factor analysis. Countries that are most dependent on tourism are dominated by the first component, while others group around investments, government regulations and specific factors that do not play a crucial role in the overall economy. This difference could significantly impact tourism development policies, as it suggests that the tourism sector cannot be viewed as a universal economic model that operates under the same conditions in every country.

It is interesting to note that business tourism spending shows a slightly different pattern compared to other variables. Its connection with PC1 indicates that business tourism is part of the broader economic picture of tourism, but its strong correlation with higher-order components suggests that business tourism is not evenly distributed among countries. Some countries have a highly developed conference and business travel industry, while others do not play a significant role in this segment. This difference is clearly reflected in the factor loadings, where we see that business tourism partially deviates from the dominant tourism pattern.

When we look at the direct contribution of tourism to the economy, we see that this variable shows a negative correlation with one of the higher-order components. This may indicate that in some countries, although tourism has high economic significance, its direct monetary benefits may be distributed differently

compared to other aspects of tourism. This phenomenon is particularly evident in countries where tourism has a strong multiplier effect and where tourism does not only generate direct revenues through hotels and restaurants but also creates additional economic effects in related sectors.

It is also interesting that outbound tourism expenditure does not have a strong connection with any of the first few components. This suggests that the amount citizens of a particular country spend on traveling abroad does not significantly differ between countries in a way that would affect key patterns of variability. In other words, while domestic tourism activity is one of the main factors shaping a country's tourism profile, outbound tourism does not play a significant role in the overall data structure.

5. CONCLUSIONS

When we compare the results of the PCA analysis with the data on the share of tourism in GDP in AII countries, we gain interesting insights into how tourism shapes the economies of these countries. The principal component analysis has shown which variables are key in defining tourism economies, while GDP data provide concrete evidence of the significance of tourism in each country.

Considering the overall structure of the heatmap, we can conclude that tourism is an extremely complex phenomenon, where economic effects are not evenly distributed among countries. While some states rely on mass tourism with a strong domestic contribution, others depend on large investments and business tourism, and some are heavily reliant on government funding and strategic support. This analysis enables the identification of key drivers of tourism development and the differentiation of essential factors that shape tourism economies worldwide.

While the factor analysis and heatmap of factor loadings provide valuable insights into the structure of tourism data and the relationships between key variables, there are several limitations to this reasoning that should be considered.

Firstly, the dominance of the first component in explaining the majority of the variance may oversimplify the complexity of tourism dynamics. Although PC1 captures the overall economic significance of tourism, it may mask important nuances and interactions between variables that are critical for a comprehensive understanding of the sector. This could lead to an overemphasis on certain variables while neglecting others that may also play significant roles.

Secondly, the reliance on high factor loadings to interpret the importance of variables assumes that these loadings are stable and consistent across different

contexts and datasets. However, factor loadings can be influenced by sample size, data quality and the specific characteristics of the dataset being analysed. This variability can affect the robustness and generalisability of the conclusions drawn from the analysis.

Thirdly, the interpretation of components as distinct factors (e.g., economic contribution, investments, government support) may not fully capture the interconnectedness and interdependencies between these factors. Tourism is a multifaceted industry influenced by a wide range of economic, social, and environmental factors. Simplifying these influences into discrete components may overlook the complex interactions that drive tourism development and sustainability.

Additionally, the analysis assumes that the identified components are equally relevant and impactful across all countries in the dataset. This may not be the case, as different countries have unique tourism profiles, policies and economic conditions that shape their tourism sectors. The conclusions drawn from the factor analysis may therefore be more applicable to some countries than others, limiting the universality of the findings.

Lastly, the focus on quantitative data and statistical techniques may neglect qualitative aspects of tourism that are equally important for understanding the sector. Factors such as cultural significance, visitor experiences and community impacts are difficult to capture through quantitative measures alone but are crucial for a holistic understanding of tourism.

In conclusion, the PCA analysis and data on tourism's share in GDP demonstrate a high level of mutual consistency. Countries where tourism is a dominant economic factor are clearly recognised in the first principal component, while countries with specific tourism development models are linked to components that reflect state investments, business tourism and infrastructure projects. This analysis not only enables the understanding of current trends but also allows for predictions about the future development of tourism in the region, depending on how individual countries approach further investments and tourism strategies.

The factor loading analysis and data on the share of tourism in GDP clearly show that there is no universal model for tourism development. Countries traditionally reliant on tourism, such as Croatia and Montenegro, showed the highest association with the first principal component, while countries that develop tourism through investments and government regulation were more linked to the second and third components. These differences are not just theoretical, they are

visible through real economic indicators and clearly demonstrate how different countries shape their tourism policies.

In the long run, such analyses can help define strategies for sustainable tourism development, as they help understand which countries have already utilised their tourism potential and which still need to invest resources in its expansion. Ultimately, understanding this data is not just statistical but can play a key role in making economic and political decisions that will determine the future of tourism in the AII region.

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Conflict of interests

The authors declare there is no conflict of interest.

REFERENCES

Abdi, H., & Williams, L. J. (2010). Principal component analysis. *Wiley interdisciplinary reviews: computational statistics*, *2*(4), 433-459. https://doi.org/10.1002/wics.101

Buhalis, D., & Law, R. (2008). Progress in information technology and tourism management: 20 years on and 10 years after the Internet. *Tourism Management, 29*(4), 609-624. https://doi.org/10.1016/j.tourman.2008.01.005

Dwyer, L. (2022). Foreign direct investment in tourism: host destination opportunities and challenges. *Tourism and foreign direct investment,* 11-30. https://www.taylorfrancis.com/chapters/edit/10.4324/9781003155492-4/foreign-direct-investment-tourism-larry-dwyer

Earl, A., & Hall, C. M. (2021). *Institutional theory in tourism and hospitality*. Routledge.

Gladstone, D. L., & Fainstein, S. S. (2001). Tourism in US global cities: A comparison of New York and Los Angeles. *Journal of Urban affairs, 23*(1), 23-40. https://doi.org/10.1111/0735-2166.00073

Gössling, S., Scott, D., & Hall, C. M. (2020). Pandemics, tourism and global change: A rapid assessment of COVID-19. *Journal of Sustainable Tourism, 29*(1), 1-20. https://doi.org/10.1080/09669582.2020.1758708

Günter, S., Schraudolph, N. N., & Vishwanathan, S. V. N. (2007). Fast Iterative Kernel Principal Component Analysis. *Journal of Machine Learning Research*, *8*(8).

Hall, C. M. (2024). Introduction: Tourism Policies, Planning and Governance. In *The Wiley Blackwell Companion to Tourism*, Second Edition. Wiley.
Hall, C. M., & Williams, A. M. (2008). *Tourism and Innovation*. Routledge
Jolliffe, I. (2002). *Principal Component Analysis*. Springer. https://doi.org/10.1007/b98835
OECD. (2024). *OECD Tourism Trends and Policies 2024.* OECD Publishing, Paris. https://doi.org/10.1787/80885d8b-en.
Page, S. J., & Connell, J. (2020). *Tourism: A Modern Synthesis*. Routledge. https://doi.org/10.4324/9781003005520
Papatheodorou, A. (2004). Exploring the evolution of tourism resorts. *Annals of Tourism Research, 31*(1), 219-237. https://doi.org/10.1016/j.annals.2003.10.004
Ritchie, J. R. B., & Crouch, G. I. (2003). *The Competitive Destination: A Sustainable Tourism Perspective*. CABI Publishing.
Sharpley, R., & Telfer, D. J. (2014). *Tourism and Development: Concepts and Issues*. Channel View Publications.
UNWTO (2025). *World Tourism Barometer 2025*. United Nations World Tourism Organization. https://doi.org/10.18111/wtobarometereng
UNWTO. (2025). *Tourism statistics database*. World Tourism Organization. https://www.unwto.org/tourism-statistics/tourism-statistics-database
World Bank. (2022). *Global Economic Prospects: Tourism and Economic Recovery.* https://openknowledge.worldbank.org/entities/publication/785d9bcf-89e5-5a42-925b-a996f2861208
WTTC. (2023). *Economic Impact of Travel & Tourism 2023*. World Travel & Tourism Council.

ФАКТОРСКА АНАЛИЗА ТУРИСТИЧКОГ СЕКТОРА У ЗЕМЉАМА ЈАДРАНСКО-ЈОНСКЕ ИНИЦИЈАТИВЕ

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САЖЕТАК

Туризам представља кључни сегмент економског развоја у земљама Јадранско-јонске иницијативе (АІІ), доприноси бруто домаћем производу (БДП) и утиче на запосленост, инвестиције и трговински биланс региона. Ова анализа испитује трендове настајања и преусмјеравања туризма у осам АІІ земаља: Албанији, Босни и Херцеговини, Хрватској, Грчкој, Италији, Црној Гори, Србији и Словенији, у периоду од 1995. до 2024. године.

Рад примјењује мултиваријациони приступ како би се идентификовали кључни фактори који обликују конкурентност дестинација и доприносе стабилности туристичког сектора. Студија разматра утицај инфраструктурних инвестиција, политичке стабилности, макроекономских показатеља, државних политика о субвенцијама у туризму, као и ефекте пандемија и глобалних економских криза на токове туризма.

Резултати показују да су Хрватска, Грчка и Црна Гора лидери у туристичкој индустрији, с тим да туризам чини више од 10% БДП-а. Албанија и Словенија биљеже стабилан раст, док Италија, иако економски развијенија од осталих анализираних земаља, има мањи удио туризма у односу на своје индустријске и технолошке секторе. Босна и Херцеговина и Србија суочавају се с изазовима у привлачењу страних туриста због инфраструктурних ограничења и недовољно развијене промоције.

Закључци студије наглашавају важност стратегија одрживог развоја туризма, повећаних инвестиција и регионалне сарадње у циљу ублажавања ефеката сезоналности и јачања отпорности сектора на глобалне економске промјене.

Кључне ријечи: *факторска анализа, јадранско-јонска иницијатива, туризам, економски раст.*

THE EFFECTS OF SOUTH AFRICA'S MACROECONOMIC FACTORS ON YOUTH ENTREPRENEURSHIP

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ABSTRACT

This study investigates the effects of South Africa's macroeconomic factors on youth entrepreneurship using the Auto-Regressive Distributed Lag (ARDL) model, with quarterly data spanning from 2008Q1 to 2022Q4. The analysis reveals that macroeconomic variables, including GDP, human capital, interest rates, gross fixed capital formation, and youth unemployment influence youth entrepreneurship in both short and long runs. Notably, human capital and interest rates show significant relationships with education fostering entrepreneurship, while high interest rates constrain it. Although GDP and unemployment have positive associations with entrepreneurship, their effects are not statistically significant. The findings highlight the need for policies that prioritise youth entrepreneurship through improved education, supportive infrastructure, and alternative financing mechanisms. Such interventions could enhance youth-led entrepreneurial activities, mitigate unemployment, and promote sustainable economic growth. The study underscores the importance of targeted macroeconomic strategies to empower South African youth entrepreneurs and addresses gaps in existing literature on the economic determinants of entrepreneurship.

1. INTRODUCTION AND BACKGROUND

Youth entrepreneurship refers to young individuals applying practical entrepreneurial traits such as initiative, innovation, creativity, and risk-taking, while utilising the necessary skills for success in self-employment or small start-up businesses (Chigunta, 2002, p.2). As Chigunta (2002, p.12) explains,

while progress in youth entrepreneurship may be linked to certain age stages, the development of an entrepreneur is not a rigid, linear process and is not confined to a particular age group. Therefore, young entrepreneurs can be found at various points along the entrepreneurial continuum.

Like many business owners, young entrepreneurs often encounter numerous challenges, such as limited access to institutional capital, inadequate working spaces, a lack of business management skills, limited capacity for product development, insufficient ongoing business support, and poor or non-existent financial record-keeping (Chigunta, 2002, p.12). Additional difficulties highlighted by Malyadri and Sumana (2012, p. 379-380) include entrepreneurial isolation, lack of business networks, limited access to financial resources and advisory services, insufficient self-sustaining resources, absence of a solid credit history, inadequate collateral to secure loans, high interest rates, and a lack of distinction between business ownership and control. Moreover, young entrepreneurs often struggle with limited on-the-job training, lack of experience, and insufficient mentorship (Malyadri & Sumana, 2012, p. 379-380).

In response to these challenges, governments worldwide have implemented strategies to provide both financial and non-financial support to young entrepreneurs (OECD, 2001). Non-financial support services focus on providing essential business management tools, training to improve performance and productivity, and business idea development aimed at creating viable ventures (Awogbenle & Iwuamadi, 2010, p.834). Financial support, on the other hand, includes grants or microloans to help young people start or expand businesses (ILO, 2012, p.1-2). These interventions aim to foster entrepreneurial activities among the youth at various stages of their business ventures, and ultimately boost youth entrepreneurship development.

South Africa's youth policies (see Republic of South Africa, 2009: 26-27, 2015: 17-18, 2020: 23) emphasise promoting youth entrepreneurship, primarily, as a response to the country's high levels of youth unemployment. For example, Statistics South Africa reported youth unemployment rates of 35.7% in 2010, 41.0% in 2019, and 46.3% in 2022. In contrast, only 12% of employed youth were engaged in entrepreneurial activities in 2022, though this marked a 2% increase from 2017. Additionally, the Global Entrepreneurship Monitor (GME) South Africa reported low levels of early-stage entrepreneurial activity among 18 to 24-year-olds, with only 8% involved in 2022, and 10.4% among those aged 25 to 34. Likewise, the rate of established business ownership was also low, with only 0.6% of 18 to 24-year-olds and 0.9% of 25 to 34-year-olds owning established businesses (see Bowmaker-Falconer, Meyer & Samsami, 2023).

The increasing number of unemployed youth in South Africa, combined with low levels of youth entrepreneurship, underscores the importance of continued research in this area. While Hughes and Schachtebeck (2017) recognise that both personal factors (such as perceptions, demographics, background, and attributes) and contextual factors (such as the economic environment, available resources, and support) influence the entrepreneurial dynamics of young people in South Africa, there remains a gap in the literature. Many studies conducted in South Africa tend to be descriptive and/or qualitative in nature, and mostly with a focus on the entrepreneurial intentions of young South Africans rather than on how economic factors impact youth entrepreneurship (see for instance, Musengi-Ajulu, 2010; Fatoki & Chindoga, 2011; Fatoki, 2011; Skosana, 2012; Pendame, 2014; Memani & Fields, 2014; Malebana & Swanepoel, 2015; Mbuya, Diniso & Mphahlele, 2016; Zwane, Radebe, & Mlambo, 2021; Ndebele, Ndlovu, Mlambo & Thusi, 2022; Ndlovu, Radebe, Mlambo & Nkonde, 2024). This paper is therefore valuable, as it seeks to explore the relationship between South Africa's economic environment and youth entrepreneurship. Specifically, it examines the short- and long-term effects of macroeconomic factors on youth entrepreneurial activities in the country.

2. ENTREPRENEURSHIP AND THE MACROECONOMIC ENVIROMENT

Due to the complex and multifaceted nature of entrepreneurship, the literature has yet to provide a single, universally accepted definition of the phenomenon (OECD, 2017, p.18). Thus, understanding entrepreneurship requires an integrative approach that acknowledges the entrepreneurial process as starting with opportunity recognition, followed by the discovery and exploitation of opportunities, and culminating in execution (Shane, 2003, p.10-11). As illustrated in Figure 1, the entrepreneurial process is interconnected at all stages with both individual factors (such as psychological traits and demographics) and environmental factors (including industry-specific conditions and the broader macro-environment).

The interplay between the macroeconomic environment and entrepreneurship is explained by Casson (2010, p.3), in that volatility in the macro-economy drives demand for entrepreneurship, while the supply of entrepreneurship is determined by the availability of entrepreneurial people. This interaction of demand and supply, thus, determines both entrepreneurial reward as well as entrepreneurial activity in the economy Casson (2010, p.3). This is supported by studies that recognise that macroeconomic factors, indeed, play a significant role in shaping

entrepreneurship (Sipos-Gug & Badulescu, 2015; Fritsch & Kritikos, 2016; Ashena, Vosoughi & Hoshyarmoghadam, 2022; Vyrostková & Kádárová, 2023). Ashena, Vosoughi & Hoshyarmoghadam (2022), assert that at every stage of a business - from startup to growth, and to sustainability, the performance of macro-economy is crucial. As a result, shifts in economic conditions can influence decision-making about starting or continuing a business.

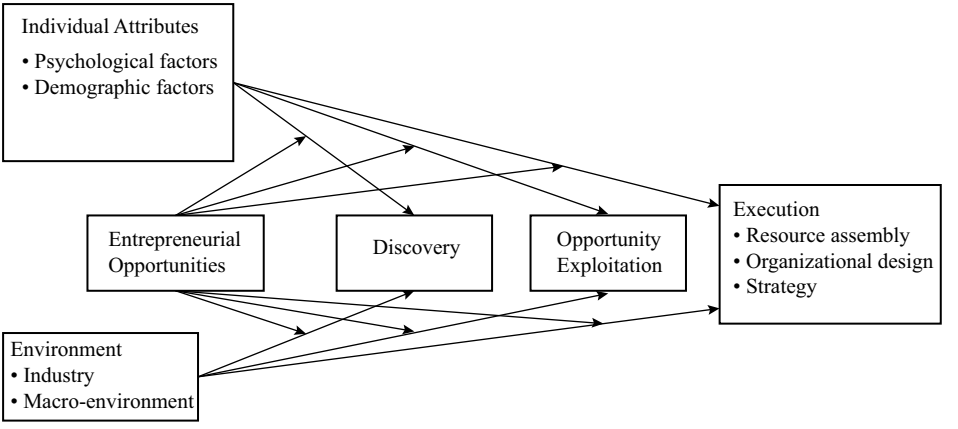

Figure 1: Entrepreneurial process
Source: Shane (2003, p.11)

Although the entrepreneurial process remains fundamentally the same for both young and older people, Chigunta (2002) argues that the involvement of youth in entrepreneurship can have unique characteristics specific to their age group. Thus, this paper aims to explore how several macroeconomic variables - namely gross domestic product (GDP), human capital, interest rates, gross fixed capital formation (GFCF), and unemployment – affect, specifically, youth entrepreneurship in South Africa. The expected behaviour of these variables in relation to youth entrepreneurship is outlined below:

Economic growth

A positive correlation is said to exist between entrepreneurial activity and economic growth (Wennekers & Thurik, 1999; Stam & van Stel, 2011; Smith & Chimucheka, 2014). It is therefore expected that an increase in demand as well as the expansion of markets that comes with economic growth would propel young people to venture into entrepreneurship.

Human capital

Investment in education and skills development is found to enhance entrepreneurial activities (Van der Sluis, Van Praag, & Vijverberg, 2008; İlhan Ertuna, & Gurel,

2011; Nega, & Schneider, 2014). Thus, higher levels of education and skills training is expected to equip young people with the essential knowledge and capabilities valuable for entrepreneurship.

Interest rates

A counter-cyclical effect is observed between interest rates and entrepreneurial activity (Angeletos & Panousi, 2011; Somoye, 2013; Jackson & Madison, 2022). Thus, higher lending rates are expected to increase the cost of borrowing, making it more expensive for young people to have access to capital for their entrepreneurial activities.

Gross Fixed Capital Formation

Investment in infrastructure development has been proven to boost entrepreneurial activities (Van de Ven, 1993; Yaluner, Chesnova, Ivanov, Mikheeva, & Kalugina, 2019). It is expected, therefore, that increased investments in fixed assets and infrastructure would support and make it easier for young people to do business.

Unemployment

High unemployment rates are expected to increase entrepreneurial activities (Kheiravara & Qazvini, 2012; Mahadea & Kaseeram, 2018; Faria, Cuestas & Gil-Alana, 2019). When job opportunities are scarce in the formal labour market, entrepreneurship offers young people an opportunity for self-employment and income generation.

3. RESEARCH METHODOLOGY

This study makes use of the Auto-Regressive Distributed Lag (ARDL) econometric model on a quarterly data series covering a period 2008Q1-2022Q4[1]. The ARDL bounds testing approach to test for long run relationships follows from studies by Asid, Razi, Mulok, Kogid & Lily (2014), and Tsaurai & Odhiambo (2012). ARDL modelling approach has several advantages. Firstly, it is a versatile tool for examining short and long-run cointegrating relationships and incorporates lags for both dependent and explanatory variables (Pesaran & Shin, 1999). Secondly, it can be used regardless of whether study variables are integrated of order zero or one (Odhiambo, 2013). Thirdly, it accommodates an adequate number of lags to capture the data generation process within a general-to-specific modeling framework (Hirnissa, Habibullah & Baharom,

1 The study makes use of secondary data from the following statistical agencies: Statistics South Africa (www.statssa.gov.za); South African Reserve Bank (www.resbank.co.za); and University of Groningen, Penn World Table 9.0 (https://doi.org/10.34894/QT5BCC)

2009). Fourthly, it yields robust results for studies with limited sample sizes and desirable small sample properties in parameter estimates (Narayan, 2005). Finally, it effectively addresses potential endogeneity in explanatory variables (Pesaran & Shin, 1999; Acikgoz & Mert, 2014).

The ARDL model can be written as follows:

$$Y_t = \alpha + \beta_1 * Y_{(t-1)} + \beta_2 * Y_{(t-2)} + ... + \beta_p * Y_{(t-p)} + \gamma X_t + \varepsilon_t$$

Where:

Y_t is the dependent variable at time t.

$Y_{(t-1)}$, $Y_{(t-2)}$, ..., $Y_{(t-p)}$ are the lagged values of the dependent variable.

X_t represents one or more independent variables.

α is the intercept term.

$\beta_1, \beta_2, ..., \beta_p$ are coefficients associated with the lagged dependent variables.

γ is the coefficient associated with the independent variable(s).

ε_t is the error term.

$\beta_1, \beta_2, ..., \beta_p$: are coefficients which represent the short-term impact of the lagged dependent variables on the current value of the dependent variable. They indicate how past values of the dependent variable influence its current value.

The ARDL model allows one to examine the long-term relationship between the dependent variable and the independent variable(s) by testing for cointegration. If the variables are cointegrated, it implies a stable long-term relationship. The functional Equation formulated for this analysis is as follows:

$$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \beta_4 X_{4t} + \beta_5 X_{5t} + \varepsilon_t$$

Where:

Y_t = *Youth entrepreneurship*

β_0 = *intercept*

X_1 = *GDP*

X_2 = *Human Capital Index*

X_3 = *Interest rates*

X_4 = *Gross Fixed Capital Formation*

X_5 = *Youth Unemployment*

ε_t = *Random error term*

β = *coefficients*

We hypothesise that the selected exogenous variables have a statistically significant positive relationship with the dependent variable, namely, youth entrepreneurship.

4. RESULTS

The data was tested for stationarity using Augmented Dickey Fuller and Phillips Perron stationarity teste. The results of the stationarity tests are reported in Tables 1 and 2 below.

Table 1: Augmented Dickey Fuller Test

	LYENTR	GDP	GFCF	HCI	INT	YUN
With Constant	-4.3625***	-11.4101***	-8.8417***	-1.7945	-4.0207***	-1.0403
With Constant & Trend	-4.4324***	-11.3149***	-8.7828***	-0.2681	-3.3998***	-3.6611***
Without Constant & Trend	-0.0664	-11.2698***	-8.9186***	-0.0020	-1.1708	1.0858
	d(LYENTR)	**d(GDP)**	**d(GFCF)**	**d(HCI)**	**d(INT)**	**d(YUN)**
With Constant	-10.9058***	-7.0025***	-6.3903***	-1.7212	-3.5499***	-11.0680***
With Constant & Trend	-10.8863***	-6.9354***	-6.2960***	-2.3201	-3.9894**	-10.9734***
Without Constant & Trend	-11.0029***	-7.0707***	-6.4577***	-1.8095*	-3.5403***	-10.9561***

Notes: (*)Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant

Source: Authors´ survey

Table 2: Phillips – Perron Test

	LYENTR	GDP	GFCF	HCI	INT	YUN
With Constant	-4.4024***	-19.1701***	-9.4688***	-1.8414	-2.5612	-1.2020
With Constant & Trend	-4.3913***	-20.4519***	-9.4417***	-0.2665	-1.9034	-3.6189**
Without Constant & Trend	-0.1044	-12.9095***	-9.5582***	1.0144	-1.1911	1.6588
	d(LYENTR)	**d(GDP)**	**d(GFCF)**	**d(HCI)**	**d(INT)**	**d(YUN)**
With Constant	-11.2066***	-81.5313***	-44.9271***	-7.6447***	-3.7152***	-12.8036***
With Constant & Trend	-11.5565***	-80.7473***	-47.7576***	-8.1672***	-4.0640**	-12.7684***
Without Constant & Trend	-11.3108***	-81.3267***	-44.5805***	-7.5498***	-3.6986***	-11.3867***

Notes: (*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant

Source: Authors´ survey

Tables 1 and 2 above both show that the data series were a mixture of I(0) and I(1); meaning that some of the data series were stationary at levels whilst others were stationary only after first differences. This make the ARDL econometric technique suitable for data analysis in this research. The ARDL results are shown next in Tables 2 and 3 below.

Table 3: Long Run Estimates

Selected model: ARDL(4,0,3,2,0,0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LYENTR(-1)	0.297150	0.141226	2.104072	0.0415**
LYENTR(-2)	0.113356	0.147897	0.766448	0.4478
LYENTR(-3)	0.044341	0.146382	0.302915	0.7635
LYENTR(-4)	-0.305915	0.142473	-2.147180	0.0377**
GDP	0.002425	0.005559	0.436283	0.6649
HCI	-0.193908	0.286233	-0.677448	0.5019
HCI(-1)	0.111923	0.367658	0.304420	0.7623
HCI(-2)	-0.676839	0.386447	-1.751443	0.0873*
HCI(-3)	0.862463	0.280912	3.070222	0.0038**
INT	-0.024981	0.025626	-0.974827	0.3354
INT(-1)	0.089940	0.041414	2.171743	0.0357**
INT(-2)	-0.042704	0.022723	-1.879379	0.0673*
GFCF	0.000627	0.003586	0.174933	0.8620
YUN	0.001472	0.002720	0.540996	0.5914
C	10.79613	2.610092	4.136302	0.0002***
R-squared	0.541777			

Notes: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1%.

Source: Authors´ survey

Table 4: Short Run estimates

Variable	Coefficient	Std. Error	t-Statistic
COINTEQ*	-0.851068	0.167731	-5.074007***
D(LYENTR(-1))	0.148218	0.161679	0.916741
D(LYENTR(-2))	0.261574	0.142420	1.836630*
D(LYENTR(-3))	0.305915	0.123161	2.483871**
D(HCI)	-0.193908	0.230171	-0.842454
D(HCI(-1))	-0.185623	0.238862	-0.777115
D(HCI(-2))	-0.862463	0.240282	-3.589372***
D(INT)	-0.024981	0.016305	-1.532134
D(INT(-1))	0.042704	0.016463	2.593889**
R-squared	0.558503		

Notes: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1%.

Source: Authors´ survey

The R-squared value of the ARDL model, both in the long and short term, stands at 54% and 55%, respectively. This signifies that the exogenous variables included in the model account for 55% of the variation observed in the dependent variable. The error correction term registers a substantial value of 85%, signifying its statistical significance at the 1% level. This implies that in the presence of any long-term disequilibrium, approximately 85% of the deviation from the long-term equilibrium is rectified.

Having presented the ARDL results, we focus on diagnostic tests to prove the adequacy and the robustness of our results. The results are presented in Table 4 to Table 6, and Figure 1 below.

Table 5: Wald Test estimations

Test Statistic	**Value**	**Df**	**Probability**
F-statistic	5.176414	(6, 50)	0.0003***
Chi-square	31.05848	6	0.0000***
Null Hypothesis: C(1)=C(2)=C(3)=C(4)=C(5)=C(6)=0			
Null Hypothesis Summary:			
Normalized Restriction (= 0)		**Value**	**Std. Err.**
C(1)		0.391308	0.132365
C(2)		0.006270	0.005160
C(3)		-0.018922	0.025229
C(4)		0.074301	0.042761
C(5)		-0.044152 0.023001	
C(6)		-0.002581	0.003284
Restrictions are linear in coefficients.			

Source: Authors´ survey

The Wald Test is performed to test the joint significance of our model. The Wald test results shown in Table 4 indicate that the null hypothesis of no joint significance is rejected and, therefore, conclude that the exogenous variables in the model are jointly significant in explaining the variations on the dependent variable.

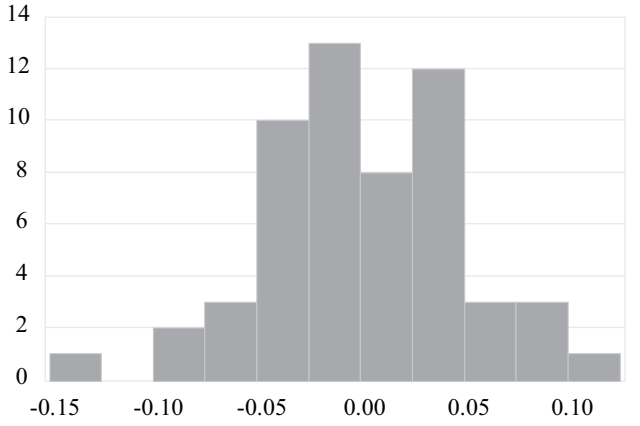

Figure 1: Normality test
Source: Authors´ survey

The Normality Test is performed to prove that the residuals are normally distributed around the mean. Figure 1 above depicts the normality test results. The Jarque-Bera test statistics is computed based on the sample skewness and kurtosis of the data. The results show p value of 0.38 and therefore we fail to reject the null hypothesis and conclude that the data is following a normal distribution.

Table 6: Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:			
Null hypothesis: No serial correlation at up to 2 lags			
F-statistic	1.394865	Prob. F(2,39)	0.2600
Obs*R-squared	3.738357	Prob. Chi-Square(2)	0.1543

The results of serial correlation test are presented in Table 5 above. The results give evidence of no serial correlation in the series.

Source: Authors´ survey

Table 7: Heteroscedasticity Test

Heteroscedasticity Test: Breusch-Pagan-Godfrey			
Null hypothesis: Homoscedasticity			
F-statistic	0.813447	Prob. F(14,41)	0.6505
Obs*R-squared	12.17339	Prob. Chi-Square(14)	0.5924
Scaled explained SS	8.702505	Prob. Chi-Square(14)	0.8496

The results of heteroscedasticity test are presented in Table 6 above. The results show evidence that the series are homoscedastic. Based on the above diagnostic tests, it can be conformed that the model used in the analysis of the data is adequate.

Source: Authors´ survey

5. DISCUSSIONS OF THE RESULTS

The long-term estimations indicate that the dependent variable, namely youth entrepreneurship, possesses the capacity to elucidate its own behavior over an extended period. The association between youth entrepreneurship and its preceding values exhibits a positive correlation up to the third preceding value, after which it becomes negative on the fourth lag. Importantly, this relationship demonstrates statistical significance at the 5% level during both first and fourth lags. Consequently, we reject the null hypothesis and affirm the presence of a relationship between youth entrepreneurship and its lagged values. This implies that the trajectory of youth entrepreneurship can be accounted for by its past values. It is noteworthy that, although economic growth, as represented by GDP in this study, exhibits a positive association with entrepreneurship, this relationship lacks statistical significance. However, it is essential to underscore that this outcome should not be misconstrued implying that economic growth is not a crucial determinant of entrepreneurship success. Economic growth is expected to enhance youth entrepreneurship by creating demand and market expansion. This is supported by Stam & Van Stel (2011), who found a positive relationship between economic growth and entrepreneurship, and by Wennekers & Thurik (1999), who highlighted that economic growth fosters an environment conducive to entrepreneurial opportunity recognition.

Investing in human capital exhibits a positively and statistically significant relationship, at the 5% level of significance, with youth entrepreneurship. This implies that educational investment plays a noteworthy role in fostering long-term youth entrepreneurship. Young individuals who have undergone formal education are more likely to succeed as entrepreneurs due to their exposure to various entrepreneurship theories and techniques. The importance of human capital in fostering entrepreneurship is well-documented. For instance, Van der Sluis, Van Praag, & Vijverberg (2008) found that education significantly enhances entrepreneurial capabilities, while İlhan Ertuna & Gurel (2011) emphasised the role of higher education in increasing entrepreneurial success rates.

Interest rates exert a dampening effect on the economy by increasing the cost of borrowing. The findings of this research reveal a negative and statistically significant relationship with youth entrepreneurship at the 10% level of significance, during the third lag. This suggests that elevated interest rates hinder entrepreneurship in South Africa over the long term. High interest rates negatively impact entrepreneurship by raising the cost of borrowing, as shown by Angeletos & Panousi (2011). Similarly, Somoye (2013) highlighted that high

borrowing costs limit access to finance, especially in developing economies, thereby reducing entrepreneurial activity.

Gross fixed capital formation, representing infrastructure development, demonstrates a positive but statistically insignificant association with entrepreneurship in the long run. Despite its lack of statistical significance, we posit that infrastructure plays a supportive role in facilitating youth entrepreneurship. Infrastructure development plays a critical role in supporting entrepreneurship. Yaluner et al. (2019) demonstrated that improvements in physical capital and connectivity boost entrepreneurial activities. This aligns with Van de Ven's (1993) findings, which highlight how infrastructure lowers barriers to entry and operational costs for entrepreneurs.

It is worth noting that youth unemployment exhibits a positive relationship with youth entrepreneurship, albeit lacking statistical significance. This implies that as the youth unemployment rate increases, some young individuals may turn to entrepreneurship in the long run. In this context, youth unemployment serves as a catalyst for fostering entrepreneurship. Youth unemployment often drives necessity-driven entrepreneurship. Mahadea & Kaseeram (2018) found a positive relationship between unemployment and entrepreneurial activities in South Africa. Similarly, Faria, Cuestas, & Gil-Alana (2009) reported that high unemployment rates encourage individuals to pursue entrepreneurship as a source of income.

The short-term estimations corroborate the findings of the long-term analysis, demonstrating that youth entrepreneurship maintains a positive and statistically significant association with its prior values in the second and third lag, evident at both 5% and 10% significance levels in the short term. It is noteworthy that the negative relationship observed between human capital investment and youth entrepreneurship in the second lag, significant at the 1% level, is not unexpected. This outcome can be attributed to the gradual and time-dependent nature of the impact of skills development on the economy. Interest rates exhibit a positive relationship with youth entrepreneurship after a single lag in the short term, reaching statistical significance at the 5% level. However, it is only in the long term that interest rates negatively impact youth entrepreneurship.

6. CONCLUSIONS AND RECOMMENDATIONS

Youth entrepreneurship development is a priority for youth policies in South Africa, particularly due to the high levels of unemployment among young people. This study concludes that the macroeconomic environment influences

youth entrepreneurship. Accordingly, South Africa's macroeconomic policies should prioritise youth entrepreneurship in order to support strategies aimed at enhancing young people's entrepreneurial activities. Notably, there is a positive relationship between youth unemployment and entrepreneurship, indicating that as unemployment rises, some young people turn to starting businesses. The importance of education and skills development is crucial, necessitating that educational institutions focus on equipping young people with essential entrepreneurial knowledge and capabilities. This education should extend beyond the classroom to include mentorship and shadowing of experienced entrepreneurs in relevant fields. Supporting youth entrepreneurial activities also requires appropriate infrastructure, such as business premises, electricity, and internet access. Without adequate infrastructure, the potential benefits of youth entrepreneurship are diminished. On the other hand, high commercial lending rates pose a significant risk to youth entrepreneurship, as many young people lack the resources to endure a high-interest-rate environment. Therefore, alternative business funding support, including grants and guarantee schemes, is crucial. Ultimately, high economic growth is vital for the success of young entrepreneurs, as low growth stifles demand and market expansion. Economic policies must intentionally support growth in sectors where youth entrepreneurship is prevalent and stimulate interest in sectors where it is underrepresented.

LIMITATIONS OF THE STUDY

The study did not isolate the specific impact of COVID-19 on youth entrepreneurship in South Africa by using dummy variables in the econometric model.

Conflict of interests

Authors declare there is no conflict of interest.

REFERENCES

Acikgoz, S., & Mert, M. (2014). Source of growth revisited the importance of the nature technological progress. *Journal of Applied Economic, 17*(1), 31-62. https://doi.org/10.1016/S1514-0326(14)60002-7

Angeletos, G.M., & Panousi, V. (2011). Financial integration, entrepreneurial risk and global dynamics. *Journal of Economic Theory, 146*(3), 863-896. https://doi.org/10.1016/j.jet.2011.02.001

Ashena, M., Vosoughi, S., & Hoshyarmoghadam, E. (2022). The role of macroeconomic factors on the development of entrepreneurship. *Journal of Innovation Ecosystem, 2*(4), 19-35. https://doi.org/10.22111/innoeco.2023.44081.1041

Asid, R., Razi, M.H.F.A., Mulok, D., Kogid, M., & Lily, J. (2014). The impact of foreign direct investment and real exchange rate on economic growth in Malaysia: Some empirical evidence. *Malaysia Journal of Business and Economics,1*(1), 73-85. https://doi.org/10.51200/mjbe.v1i1

Awogbenle, A. C., & Iwuamadi, K. C. (2010). Youth Unemployment: Entrepreneurship Development Programme as an Intervention Mechanism. *African Journal of Business Management*, *4*(6), 831-835. https://www.academia.edu/17844210/Youth_unemployment_Entrepreneurship_development_programme_as_an_intervention_mechanism

Bowmaker-Falconer, A., Meyer, N. & Samsami, M. (2023). Global entrepreneurship monitor South Africa (GEM SA). https://www.stellenboschbusiness.ac.za/sites/default/files/media/documents/2024-01/GEM_report_2022-2023.pdf

Casson, M. (2010). *Entrepreneurship: Theory, networks, history*. Edward Elgar, Cheltenham.

Chigunta, F. (2002). *Youth Entrepreneurship: Meeting the Key Policy Challenges*. Education Development Center.

Faria, J. R., Cuestas, J. C., & Gil-Alana, L. A. (2009). Unemployment and entrepreneurship: A cyclical relation? *Economics Letters, 105*(3), 318-320. https://doi.org/10.1016/j.econlet.2009.09.004.

Fatoki, O. (2011). Graduate Entrepreneurial Intention in South Africa: Motivations and Obstacles. *International Journal of Business and Management*, *5*(9), 87-98. https://doi.org/10.5539/ijbm.v5n9p87

Fatoki, O., & Chindoga, L. (2011). An investigation into the obstacles to youth entrepreneurship in South Africa. *International Business Research*, *4*(2), 161-169. https://doi.org/10.5539/ibr.v4n2p161

Fritsch, M., & Kritikos, A. S. (2016). Entrepreneurship and the business cycle. *Ifo Institute - Leibniz Institute for Economic Research at the University of Munich, 14*(03), 24-28. https://ideas.repec.org/a/ces/ifodic/v14y2016i03p24-28.html

Hirnissa, M., Habibullah, M., & Baharom, A. (2009). Military expenditure and economic growth in 5 Asian countries. *Journal of sustainable development, 2*(2), 192-202. https://doi.org/10.5539/jsd.v2n2p192

Hughes, S., & Schachtebeck, C. (2017). *Youth entrepreneurial intention in South Africa - A Systematic Review during Challenging Economic Times*. https://hdl.handle.net/10210/238111

İlhan Ertuna, Z., & Gurel, E. (2011). The moderating role of higher education on entrepreneurship. *Education+training, 53*(5), 387-402. https://doi.org/10.1108/00400911111147703

International Labour Organisation. (2012). *Key Questions on National Youth Funds: Supporting Youth to Create Sustainable Employment Opportunities*. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/project/wcms_206200.pdf

Jackson, P., & Madison, F. (2022). Entrepreneurial finance and monetary policy. *European Economic Review, 141*, 103961. https://doi.org/10.1016/j.euroecorev.2021.103961

Kheiravar, M. H., & Qazvini, M. H. (2012). Exploring the relationship between entrepreneurship and unemployment rate in industrial sector of Azarbayjan-e-

Shargi. *International Journal of Organizational Leadership, 1*(2), 45-59. https://doi.org/10.33844/IJOL.2012.60342

Mahadea, D., & Kaseeram, I. (2018). Impact of unemployment and income on entrepreneurship in post-apartheid South Africa: 1994–2015. *The Southern African Journal of Entrepreneurship and Small Business Management, 10*(1). https://doi.org/10.4102/sajesbm.v10i1.115

Malebana, M. J., & Swanepoel, E. (2015). Graduate Entrepreneurial Intentions in the Rural Provinces of South Africa. *Southern African Business Review*, *19(*1). https://doi.org/10.25159/1998-8125/5835

Malyadri, P., & Sumana, B. (2012). Youth Entrepreneurship: Key Challenges for Inclusive Development. *Advances in Asian Social Science*, *2*(1),377-382. https://www.academia.edu/25132959/Youth_Entrepreneurship_Key_Challenges_for_Inclusive_Development

Mbuya, J., Diniso, D., & Maphahlele, A. (2016). Youth entrepreneurship in South Africa: A progress review. *Conference Paper, 10th International Business Conference at Club Mykonos*, Cape Town. https://www.researchgate.net/publication/341215508_Youth_entrepreneurship_in_South_Africa_A_progressive_review

Memani, M. M., & Fields, Z. (2014). Factors Influencing the Development of Productive Entrepreneurial Behaviour Among University Students. J*ournal of Contemporary Managemen*t, *11*(1), 287-30. https://hdl.handle.net/10520/EJC157256

Musengi-Ajulu, S. (2010). What Do We Know About the Entrepreneurial Intentions of the Youth in South Africa? Preliminary Results of a Pilot Study. https://www.uj.ac.za/faculties/humanities/Department-of-Social-Work/Documents/DG_MusengiAjulu.pdf

Narayan, P.K. (2005). The savings and investment nexus from China: Evidence from Cointegration Tests. *Applied economics, 37*(17), 1979-1990. https://doi.org/10.1080/00036840500278103

Ndebele, N. C., Ndlovu, S. G., Mlambo, V. H., & Thusi, X. (2022). The Challenges of Youth Entrepreneurship from a Local Government Perspective in South Africa. *International Journal of Management, Entrepreneurship, Social Science and Humanities*, 5(2), 17–32. https://doi.org/10.31098/ijmesh.v5i2.1149

Ndlovu, S. G., Radebe, T. N., Mlambo, V. H., & Nkonde, S. D. (2024). Contextualising Entrepreneurship as A Panacea to Youth Unemployment in South Africa. *Prizren Social Science Journal*, *8*(1), 48-57. https://doi.org/10.32936/pssj.v8i1.430

Nega, B., & Schneider, G. (2014). Social entrepreneurship, microfinance, and economic development in Africa. *Journal of Economic Issues, 48*(2), 367-376. https://doi.org/10.2753/JEI0021-3624480210

Odhiambo, N.M. (2013). Financial system and economic growth in South Africa: A Dynamic Complementarity Test. *International Review of Applied Economics, 28*(1), 83-101. https://doi.org/10.1080/02692171.2013.828681

Organisation for Economic Cooperation and Development. (2001). *Putting the Young in Business: Policy Challenges for Youth Entrepreneurship*. https://www.oecd.org/employment/leed/puttingtheyounginbusinesspolicychallengesforyouthentrepreneurship.htm

Organisation for Economic Cooperation and Development. (2017). *Entrepreneurship at a glance.* https://doi.org/10.1787/entrepreneur_aag-2017-en

Pendame, R. (2014). Entrepreneurial Intent and Perseverance among South African Students. *Master's Thesis, Faculty of Commerce, Law and Management*. University of the Witwatersrand. http://hdl.handle.net/10539/15568

Pesaran, M., & Shin, Y. (1999). *An autoregressive distributed lag modelling approach to cointegration analysis*. Cambridge University Press: Cambridge.

Republic of South Africa. (2009). *National youth policy, 2009-2014*. http://www.thepresidency.gov.za/pebble.asp?relid=656

Republic of South Africa. (2015). *National youth policy, 2015-2020*. http://www.thepresidency.gov.za/download/file/fid/58

Republic of South Africa. (2020). *National youth policy, 2020-2030*. https://www.gov.za/documents/national-youth-policy-2020-2030-5-mar-2021-0000

Shane, S. A. (2003). *A general theory of entrepreneurship: An individual-opportunity nexus.* Edward Elgar, Cheltenham.

Sipos-Gug, S., and Badulescu, A. (2015). Macroeconomic factors of entrepreneurship in the European Union. *Annals of Faculty of Economics, University of Oradea, Faculty of Economics,1*(1), 601-611. https://ideas.repec.org/a/ora/journl/v1y2015i1p601-611.html

Skosana, B. V. (2012). A Study of Entrepreneurial Intentions of Students at FET Colleges in South Africa. *Master's Thesis, Faculty of Commerce, Law and Management, University of the Witwatersrand*. http://hdl.handle.net/10539/12590

Smith, W., & Chimucheka, T. (2014). Entrepreneurship, economic growth and entrepreneurship theories. *Mediterranean Journal of Social Sciences, 5*(14), 160-168. https://doi.org/10.5901/mjss.2014.v5n14p160

Somoye, R.O.C. (2013). The impact of finance on entrepreneurship growth in Nigeria: A cointegration framework. *ACRN Journal of Entrepreneurship Perspectives, 2*(2), 21-45. http://www.acrn.eu/resources/Journals/201310b.pdf

Stam, E., & van Stel, A. (2011). 4 types of entrepreneurship and economic growth. In Adam Szirmai, Wim Naudé, and Micheline Goedhuys (eds), Entrepreneurship, innovation, and economic development. *WIDER Studies in Development Economics, Oxford, 2011*, 78-95. https://doi.org/10.1093/acprof:oso/9780199596515.003.0004

Tsaurai, K., & Odhiambo, N.M. (2012). Foreign direct investment and economic growth in Zimbabwe: A dynamic causality test. *International Journal Economic Policy in Emerging Economies, 5*(2), 183-196. https://doi.org/10.1504/IJEPEE.2012.048505

Van de Ven, H. (1993). The development of an infrastructure for entrepreneurship. *Journal of Business venturing, 8*(3), 211-230. https://doi.org/10.1016/0883-9026(93)90028-4

Van der Sluis, J., Van Praag, M., & Vijverberg, W. (2008). Education and entrepreneurship selection and performance: A review of the empirical literature. *Journal of economic surveys, 22*(5), 795-841. https://doi.org/10.1111/j.1467-6419.2008.00550.x

Vyrostková, L., & Jaroslava Kádárová. (2023). Entrepreneurship dynamics: Assessing the role of macroeconomic variables on new business density in Euro area. *International Journal of Financial Studies, 11*(139). https://doi.org/10.3390/ijfs11040139

Wennekers, S., & Thurik, R. (1999). Linking entrepreneurship and economic growth. *Small business economics, 13*(1), 27-55. https://doi.org/10.1023/A:1008063200484

Yaluner, E.V., Chesnova, O.A., Ivanov, S.A., Mikheeva, D.G., & Kalugina, Y.A. (2019). Entrepreneurship development: Technology, structure, innovations. *International Journal of Recent Technology and Engineering, 8*(2), 6020-6025. https://doi.org/10.35940/ijrte.B3732.078219

Zwane, H.C., Radebe, T.N., & Mlambo, V. H. (2021). Is Youth Entrepreneurship Key to Addressing Youth Unemployment? Interrogating South Africa's Youth Unemployment Dilemma. *Journal of Social Sciences, 69*, 18-25. https://doi.org/10.31901/24566756.2021/69.1-3.2284.

ЕФЕКТИ МАКРОЕКОНОМСКИХ ФАКТОРА У ЈУЖНОАФРИЧКОЈ РЕПУБЛИЦИ НА ПРЕДУЗЕТНИШТВО МЛАДИХ

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САЖЕТАК

Ова студија истражује ефекте макроекономских фактора Јужноафричке Републике на предузетништво младих користећи модел ауторегресивног дистрибуираног заостајања, са кварталним подацима: од првог квартала 2008. године до четвртог квартала 2022. године. Анализа открива да макроекономске варијабле, укључујући БДП, људски капитал, каматне стопе, бруто инвестиције у фиксни капитал и незапосленост младих, утичу на предузетништво младих и на кратки и на дуги рок. Треба истаћи да људски капитал и каматне стопе показују значајну међусобну повезаност, при чему образовање подстиче предузетништво, док га високе каматне стопе ограничавају. Иако БДП и незапосленост имају позитивне асоцијације са предузетништвом, њихови ефекти нису статистички значајни. Налази истичу потребу за политикама које дају приоритет омладинском предузетништву кроз побољшано образовање, инфраструктуру подршке и алтернативне механизме финансирања. Такве интервенције би могле да унаприједе предузетничке активности вођене младима, смање незапосленост и промовишу одржив економски раст. Студија наглашава важност циљаних

макроекономских стратегија за оснаживање младих предузетника у Јужноафричкој Републици и бави се празнинама у постојећој литератури о економским детерминантама предузетништва.

Кључне ријечи: предузетништво младих, модел ауторегресивног дистрибуираног заостајања*, макроекономија, Јужноафричка Република.*

EFFECTS OF VALUE ADDED TAX INCREASE ON HOUSEHOLDS' WELFARE IN SOUTH AFRICA

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ABSTRACT

The South Africa's Value Added Tax increased from 14% to 15% on the 1st of April 2018 because of the compelling need to avoid budget deficits. Value Added Tax increment always leads to consumer price increase with some adverse impacts on consumers' purchasing power. This study evaluated the welfare effects of commodity price changes after the Value Added Tax increase on South African families. The data were from the National Income Dynamics Survey 2018 and the South African Consumer Price Indexes (2017/18 and 2018/19). Price elasticities were obtained from the Quadratic Almost Ideal Demand System Model and the impact of commodity price fluctuations in terms of Compensating Variation were then calculated using price elasticities. The study's conclusions provide an essential basis for an empirical examination to pinpoint the effects on welfare. The paper recommends that instead of having a uniform VAT standard rate, luxury goods should be subject to a higher VAT rate such as expensive watches, yachts and cars. Due to the large percentage of luxury goods being imported, domestic demand may not be negatively impacted, and the balance of payments may even slightly improve. Also, the study endorses that the list of items with a zero rating be expanded to include more products that the poor purchase more frequently, such as all types of bread, soaps, candles and items connected to education (such as school uniforms). Additionally, these findings are a part of a bigger investigation into quantitative evaluations of policy alternatives to guide the nation's VAT reform.

1. INTRODUCTION

Mitigating poverty and redistributing income and wealth to a considerable segment of the citizens are two biggest concerns in South Africa. These cannot be fixed unless the challenges of creating high and sustainable economic growth are addressed. Policies that specifically address these issues can help provide answers to these problems. Thus, measures that could promote employment are required. The uneven income distribution that is a feature of the South African economy could be addressed by reducing unemployment. The economy is not producing enough employment, and unexperienced workforces and youth face the effect of the crisis as firms search for trained people, with youth unemployment rates rising from 39.7% to 51.52% between 2011 and 2015 (Industrial-Development-Corporation, 2019; World-Bank-Group, 2018). At the end of the fourth quarter of 2022 the youth unemployment rate was 39.9% for those between the ages of 25 and 34 and 61% for those between the ages of 15 and 24. In general, the first quarter of 2023 saw an official unemployment rate of 32.7% (Industrial-Development-Corporation, 2023; Statistics-South-Africa, 2022a). Not to mention that over 50% of South Africans are poor (Industrial-Development-Corporation, 2019). South Africa is suffering poor economic development, inactive private investment, growing fiscal and external deficits and a high unemployment rate (Erero, 2015).

According to the Industrial-Development-Corporation (2016), real gross domestic production (GDP) in South Africa fell from 3.6% in 2011, the post-crisis peak, to just 1.9% in 2013. Moreover, in 2015, it fell to 1.3%, the lowest notable growth rate since the 2009 global financial crisis. Likewise, the private growth remained constant in 2014, down from 4.6% in 2011. The budget and account deficits were under increasing strain as a result of the GDP downturn. In 2013–14, the government's gross debt and fiscal deficits were 45.9% and 4.0% of GDP, respectively. Consequently, the government was forced to implement a fiscal adjustment program. The year 2013 saw an expansion in the account deficit to 5.8% of GDP, which was mostly financed by capital portfolio inflows because inflows of foreign direct investment stayed relatively low (Erero, 2015). South African economy expanded by only 0.3% in 2016, because of low output in the agricultural, mining and electricity sectors. However, the GDP increased by 1.3% in 2017. This modest performance was supported by forceful growth in agriculture and by the recovery in the mining output. The transport and finance sectors also made significant contributions. Nonetheless, weak domestic demand kept weighing on the manufacturing sector, resulting in a 0.2% decline in its real GDP in 2017 (Industrial-Development-Corporation, 2018).

In addition, as stated by the Industrial-Development-Corporation (2019), there was a technical recession in South Africa in the first quarter of 2018, and even though there was a rebound in the following two quarters, the GDP growth came to just 0.8% in 2018 as a whole (the rebound was after the VAT rate increase). In February 2018, the South African government proposed to increase VAT by 1%, effective from 1 April 2018, to generate additional revenue. There was a R50 billion tax income gap for the state because of the sluggish economy, which calls for immediate action. It was estimated that in 2018–19, measures to raise income tax and value-added tax earnings would yield R36 billion; a 1% increase in VAT was predicted to contribute the most, at R22.9 billion. Therefore, VAT remains a considerable source of income for the government. Nonetheless, it is crucial to take into account how this may negatively impact the welfare of ordinary individuals (National-Treasury, 2018). It is vital to know that this increase also came at a time when there was a slow growth in private and public incomes, because of the 2018 technical recession among other things. Even though VAT appears to be functioning satisfactorily overall, there are still certain issues that must be considered. Hence, the remainder of this study center on these topics. The recent increase in VAT from 14% to 15% is the driving force behind this study.

Nonetheless, as said by the National-Treasury (2018), to fulfil additional government spending obligations and stop the public finances from further deteriorating, the increase was necessary. However, households in South Africa are facing mounting pressure due to limited income growth compared to living expenses; yet, high levels of debt combined with rising interest rates make it difficult to obtain new credit, and job uncertainty has damaged consumer confidence and impacted household spending, which increased by 1.6% in 2017 (Industrial-Development-Corporation, 2018). Sekwati and Malema (2011) argued that in times where there is a slow growth of households' income, only a few expect a rise in Value Added Tax. This essentially reduces households' consumption. A higher consumption tax could make it more difficult for poor households to buy nutritious food. Since the rise was suggested, concerns have been expressed in Parliament and other forums over how the VAT would affect low-income and impoverished households. The problem of this study is that a rise in Value Added Tax rate is more likely to raise the prices of consumers' goods and services and reduce South African households' consumption. Given that most of the population is poor and low-income earners, poor households' consumption levels will be negatively impacted by this rise. However, certain basic items in South Africa are exempted and zero-rated from VAT to provide a relief to low-income families that offer most of their income on consumption.

These items have no VAT on them (National-Treasury, 2018; Roos et al., 2020). This study focuses on VAT-taxable supplies (commodity items that are subjected to VAT) to compare the relationship amongst them and understand the overall tax system and therefore determine the extent that VAT rate changes have on household consumption. The aim of the study is to investigate how a VAT rise might affect the welfare of South African households.

2. MATERIALS AND METHODS

This research made use of the National Income Dynamics Survey (NIDS) 2018 (wave 5) of South Africa. The survey provides relevant data on family spending on single products by total spending and level of income, which was used to understand the consequence of increased prices for consumers. The survey included four different forms of structured questionnaires, the majority of which were connected to expenditures and included questions about the structure and organisation of the households. Over 28000 participants from 7300 homes nationwide were included in the study's nationally representative sample when it began in 2008. Every two years, the survey is administered to the same household members. Children born to continuous sample member mothers are added to the sample of continuous sample members and are tracked. Furthermore, 2 775 additional household members were included in 2017, resulting in a total of 37 368 people successfully interviewed in this study. The National Income Dynamics Survey only includes expenditure data, not price or quantity purchase data. This is a restriction in terms of estimating consumer demand in South Africa, and it also applies to this research. It was then crucial to assess the prices encountered by households using alternative data collection, the best of which being the price data set gathered and primarily utilised in generating the Consumer Price Index (CPI) by Statistics South Africa. According to Van Oordt (2016), this price information set is gathered by fieldworkers. They are used in field-based collection to record real prices at sample outlets. This collection occurs every month and primarily contains prices for goods, while certain pricing for services is also included. Certain services are collected monthly, while others are collected at other periods.

Prices for a particular good or service gathered from several municipal areas are averaged for each of the provinces of the country for the CPI data set. Following the international classification standard, the NIDS expenditure items were coded using the "Classification of Individual Consumption According to Purpose (COICOP)". The goal is to establish a framework of homogeneous categories of commodities and services within households' consumption expenditures

(United-Nations, 2018). The Consumer Price Index (CPI) capture price increases for commodities and services and it is a measure of prevailing inflation rate. With the COICOP classification approach, consumers' goods were classified into some categories (Statistics-South-Africa, 2017). In this study, households' consumption expenditures were all considered.

Empirical model of welfare of price increment

Compensating Variation (CV)

The welfare effect of consumers' price changes can be evaluated by the money metric indirect utility function. We can calculate the relative welfare of consumers in reaction to alterations in commodity prices by making a comparison between their pre-reform and post-reform utility levels using a set of reference prices. As is customary in this body of literature (Friedman & Levinsohn, 2002; Leyaro et al., 2010; Minot & Goletti, 2000; Niimi, 2005; Vu & Paul, 2011), we define the compensating variation as the welfare impact of consumers' price changes. It measures the additional sum of money required by a person following a price change to regain their initial utility (Leyaro et al., 2010). Using the utility function to express CV, suppose the price of commodities changed from $P^0=(P_1^0,\ldots,P_n^0)$ to $P^1=(P_1^1,\ldots,P_n^1)$, while income remained at M^0 utilities would be maximized at $U^*(P^0, M^0)=U^0$ and $U^*(P^1, M^0)=U^1$ respectively (see (Deaton & Muellbauer, 1980). The amount of money required for the consumer to maintain the utility at U^0 is the CV. The expenditure function can also be used to derive the CV, which is the expenditure that would be required for the first utility level U^0 to be maintained. Note that expenditures will be C (P^0, U^0) and C (P^1, U^0) at price P^0 and P^1, respectively, and the difference between these is the CV. CV will be positive/negative if the welfare following the price shift is less/more than it was during the first time. The quantities consumed to obtain the expression are yielded by the partial derivatives of the lowest expenditure function about price.

$$\Delta \ln C \approx q \Delta \ln p \quad \ldots\ldots 1.$$

Note that q denotes a $1\times k$ row vector for all the commodities, Δp denotes a $1\times k$ column for the price vector, and k is the total number of the commodity groups. Equation 1 can be rewritten as a budget share function, w, and price, $\Delta \ln p$. This will yield

$$\Delta \ln C^h \approx \sum_{i=1}^{k} w_i^h \Delta \ln p_i^h \quad \ldots\ldots 2.$$

In equation 2, *i* is the commodity's subscript for each household (*h*). The budget share is obtained by dividing the amount spent on the item prior to the reform by the overall amount spent by families on all goods. For the price changes to have any meaningful distributional impact, they must result from shifts in the relative prices as well as differences in the families' budget share. The substitution effects could be substantial in South Africa given the price changes in 2018, thus (1) and (2) could not be reliable indicators of household welfare. The second order Taylor series expansion approximation can be used to calculate the welfare difference given households' own and cross-price elasticities. Going back to the minimum expenditure function, this is expanded as.

$$\Delta \ln C \approx q \Delta \ln p + \frac{1}{2} q p^T s \Delta \ln p \quad \text{..... 3.}$$

Where q and $\Delta \ln p$ are commodity groups and price changes vector before and s is a $1 \times k$ matrix of compensated price elasticities. As for (2) we can reformulate this expression in terms of budget shares and proportional price changes as.

$$\Delta \ln C^h \approx \sum_{i=1}^{n} w_i^h \Delta \ln p_i^h + \frac{1}{2} \sum_{i=1}^{k} \sum_{j=1}^{k} C_{ij} \Delta \ln p_i^h \Delta \ln p_j^h \quad \text{..... 4.}$$

C_{ij} contains the Slutsky derivatives *ij* and is defined by the expression.

$$C_{ij} = \frac{P_i S_{ij} P_j}{C^h} \quad \text{..... 5.}$$

C_{ij} can be demonstrated to be equal to $w_i \varepsilon_{ij}$ through algebraic manipulation, where *ij* represents the commodity group *i*'s Hicks compensated price elasticity with regard to price change and group *j*, so (29) turn into (Friedman & Levinsohn, 2002; Leyaro et al., 2010).

$$\Delta \ln C^h \approx \sum_{i=1}^{k} w_i^h \Delta \ln p_i^h + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} w_i^h \varepsilon_{ij} \Delta \ln p_i^h \Delta \ln p_j^h \quad \text{..... 6.}$$

Equation (6) shows that the significance of a commodity in the family consumption basket and the magnitude of price changes both affect the welfare effects. To determine how price changes affected South African families' consumption, the two compensating variation conditions in (2) and (6) were applied. Also, prices, budget shares and family characteristics are needed; the terms $\Delta \ln p_i^h$

(proportionate change in price) and ε_{ij} (compensated price elasticities). The following presents the methods that will be used to measure these.

Proportionate price changes

To derive the percentage change in prices $\Delta \ln p_i^h$ required for the model in the equation (2) and (6), calculations were made to determine the proportionate change in observed prices between the survey and CPI periods.

Estimating consumer response

To estimate the response of consumers in South Africa because of price increases of commodities, we could have adopted the model established by Deaton (1987, 1988, 1990, 1997), the Deaton Unit Value Model. Typically, surveys gather information from a sample of households spread across several geographically separated clusters or regions. Nonetheless, the model requires quantities of commodity items purchased by households which were not available in the NIDS data but only in expenditure data. Therefore, the study used consumer responses obtained from QUAIDS for estimation. The budget share and price logarithm were calculated based on market prices, socio-demographic variables, and the logarithm of total household expenditure per capita using within-cluster (rural vs. urban) information. This was done using price data obtained from the Consumer Price Index. Price elasticities were used to calculate CV and, in this study, the entire demand system was estimated following Ackah and Appleton (2007), Pons (2011) and Attanasio et al. (2013).

The demand models

The Almost Ideal Demand System (AIDS) model developed by Angus Deaton and John Muellbauer (1980) is the method for demand analysis that has been most frequently utilised in the literature over the past decades. In fact, the AIDS model includes a number of desired demand qualities, including the ability to test for homogeneity and symmetry through linear restriction, among others (Barnett & Seck, 2008; Holt, 2002; Taylor, 2014). However, more recently Banks et al. (1997) expanded the AIDS model by demonstrating that the optimal form for some customer preferences is of a quadratic nature as opposed to the linear form in the basic AIDS. The QUAIDS model also keeps the AIDS model's favorable demand characteristics and compatibility with theory.

Formally, the share equations in the Banks et al. (1997) QUAIDS model are:

$$w_i = \alpha_i + \sum_{j=1}^{k} \gamma_{ij} InP_j + \beta_i In\left[\frac{m}{a(p)}\right] + \frac{\lambda_i}{b(p)}\left\{In\left[\frac{m}{a(p)}\right]\right\}^2 + \varepsilon_i \quad \text{..... 7.}$$

Where w_i is a household's expenditure share for commodity *i* defined as $w_i = \frac{P_i q_i}{m}$ and $\sum_{i=1}^{k} w_i = 1$.

Alternatively, the following limitations are necessary for the demand theory:

Adding up: $\sum_{i=1}^{n} \alpha_i = 1 \quad \sum_{i=1}^{k} \beta_i = 0 \quad \sum_{i=1}^{n} \gamma_{ij} = 0 \quad \sum_{i=1}^{n} \lambda_i = 0$ ..... 8.

Homogeneity: $\sum_{i=1}^{n} \gamma_{ij} = 0$ ..... 9.

Slutsky symmetry: $\gamma_{ji} = \gamma_{ij}$ ..... 10.

In this study, the QUAIDS model was implemented while considering sociodemographic factors. Undoubtedly, household behavior, including demand and how much is spent on what, can be influenced by demographic considerations (Polack & Wales, 1981; Sola, 2013). Demographics were taken into account in this study using Ray (1983) 'demographic scaling' approach, as in Poi (2012). This method closes the gap between the effects of changing pricing and changing demography (Polack & Wales, 1981). Using *z* as a vector of *s* household attributes in the most basic situation, the household size is represented by the scalar *z*. Let $e^R(p, u)$ indicate the reference household's spending function for a single adult.

For every home, Ray (1983) uses an expenditure function of the following form:

$$e(p,z,u) = m(p,z,u)^* e^R(p,u) \quad \text{.....11.}$$

Additionally, Ray (1983) breaks down the scaling function as $m_0(p,z,u) = \bar{m}_0(z)^* \varnothing(p,z,u)$

Based on the features of the household, the first term in this case measures the growth in spending in a household, without advocating for alterations to patterns of consumption. The second term adjusts for shifts in comparative prices and specific items purchased. QUAIDS parameterises, in accordance with Ray (1983) are: $\bar{m}_0(z)$ as $\bar{m}_0(z) = 1 + \rho' z$

Where ρ is a vector of parameters to be expected. The following is the equation for the expenditure share expenditure:

$$w_i = \alpha_i + \sum_{j=1}^{k} \gamma_{ij} InP_j + (\beta_i + \eta_i' z) In\left\{\frac{m}{\bar{m}_0(z)a(p)}\right\} + \frac{\lambda_i}{b(p)c(p,z)}\left[In\left\{\frac{m}{\bar{m}_0(z)a(p)}\right\}\right]^2 \quad \text{... 12.}$$

Where $c(p,z)=\prod_{j=1}^{k} p_j^{\eta_i' z}$

The adding-up condition requires that $\sum_{j=1}^{k} \eta_{rj}=0$ for $r=1,\ldots,s$

When allowing for changes in the price of commodity good *j*, the uncompensated price elasticity for the commodity group *i* is:

$$\varepsilon_{ij}=-\delta_{ij}+\frac{1}{w_i}(\gamma_{ij}-\left[\beta_i+\eta_i' z+\frac{2\lambda_i}{b(p)c(p,z,)}In\left\{\frac{m}{\bar{m}_0(z)a(p)}\right\}\right]$$

$$*(\alpha_j+\sum_l \gamma_{jl} Inpt)-\frac{(\beta_j+\eta_i' z)\lambda_i)}{b(p)c(p,z,)}\left[In\left\{\frac{m}{\bar{m}_0(z)a(p)}\right\}\right]^2 \quad \text{..... 13.}$$

For commodity group *i*, the expenditure elasticity is:

$$\mu_i=1+\frac{1}{w_i}\left[\beta_i+\eta_i' z+\frac{2\lambda_i}{b(p)c(p,z,)}In\left\{\frac{m}{\bar{m}_0(z)a(p)}\right\}\right] \quad \text{..... 14.}$$

We use the Slutsky equation to derive the compensated price elasticities:

$$\varepsilon_{ij}^c=\varepsilon_{ij}+\mu_i w_j \quad \text{..... 15.}$$

Note: The parameters that need to be estimated are all the lowercase Greek letters except for α_0. Household size and region are two demographic factors that were employed in this research. As recommended by Poi (2012), iterated feasible generalised non-linear least squares are used to estimate the parameters, which, when applied to this class of problems using Stata's "nlsur" command, are equivalent to the multivariate normal maximum likelihood estimator. It is crucial to discuss two major data issues at the very least after the demand model presentation, which include, establishing commodity categories and group prices in demand systems.

Data problems

In the opinion of Varian (2010), utility maximisation theory indicates that a household allocates its budget to all items while considering its own income, the price of all other commodities, and how much a specific commodity cost. Due to the complexities of experimentally evaluating each consumer's budget allocation on all items, these goods are typically bundled into bigger commodity

groupings. This method also reduces concerns with pricing multicollinearity. The generalised composite commodity theorem, which treats items whose prices rise or fall equally as a single good, is one of two techniques that are commonly used in commodity grouping (Hicks, 1936; Lewbel, 1996). For this reason, according to Angus Deaton and John Muellbauer (1980), since relative prices in fact change so much, the composite commodity theorem is only applicable in empirical research.

The second technique is separability which groups items based on the preferences of the consumer. Angus Deaton and John Muellbauer (1980) pointed out that commodities are classified such that "preferences within a group can be described independently of quantities in other groups". Preferences for particular products are clustered together when they are only weakly separable. Although weak separability can be evaluated empirically, our work did not employ these methods because they are frequently restricted to time series data. Furthermore, Bopape and Myers (2007) pointed out that the effectiveness of these tests is limited by multicollinearity in aggregate pricing data. Thus, weak separability is typically expected, as this study makes the same assumption. This suggests that the possibility of establishing sub-utility functions for every category of commodities is anticipated, and that total utility will be produced by adding the values of these sub-utilities.

One common challenge in evaluating demand systems is the absence of expenditures on commodity groupings of items. Such zero spending commodity groupings result in coefficients that are calculated incorrectly, and excluding households with zero spending on commodity groups causes selection bias. Several strategies for addressing the problem have been presented (for instance, see (Shonkwiler & Yen, 1999)), nevertheless these techniques are not adopted. The study seeks to estimate household demand since household response toward changes in VAT policy is of interest. Households that did not spend on all goods and services for the survey were deleted to solve the zero-spending problem. In addition, those with no food spending were excluded. This technique appears sensible, given that a household is likely to incur some expenses throughout the period of the survey. Furthermore, several weakly separable categories of products with observed zero spending were grouped together, as demonstrated by Blundell and Robin (2000).

Similarly, COOICP commodity groups were reduced from 12 to 8. Communication and information; education; accommodation and restaurants; and recreation, sports and culture commodity groups were removed because of a greater number of zero expenditures observed. These strategies considerably decreased the

amount of zero expenditures that were detected, although it should be noted that more or less zero spending that were still included in the sample place limitations on this work. No further steps were taken in order to prevent selection bias. After addressing the issue of apparent zero expenditures and stating that there is little separability in the grouping of commodities, COICOP items in the National Income Dynamics Survey 2018 were categorised into eight spending categories for the purposes of the full demand system. Last of all, establishing indicative pricing for each of the eight expenditure groups is a methodologically challenging task because prices are absent from the data from South African expenditure surveys (especially as code to simplify this task is unlikely to be produced). The consumer price index data collection includes monthly prices for eight hundred and thirty different goods and services for each province of the country. Prices are given for specific items rather than categories of commodities. It is also feasible to acquire the actual weight of consumable items. Because the data collection approach is not impacted by quality differences, it improves price accuracy. It does, however, increase the technical complexity involved in figuring out group prices.

Data limitations

Only expenditure data, not price or quantity purchase information, is included in the National Income Dynamics Survey. This is a restriction in terms of estimating consumer demand in South Africa, and it also pertains to the investigation discussed in this study. It was necessary to use a distinct set of data, the CPI, to determine the prices that households faced. Likewise, there was a greater number of identified zero expenditures on commodity groups. However, this is a common problem in evaluating demand systems. Such zero spending commodity categories produce incorrect coefficients estimated, and eliminating families with zero expenditure on commodity groups results in selection bias. Nonetheless, several strategies for dealing with these issues were presented, discussed and addressed.

Furthermore, because the data from South African expenditure surveys do not include prices, establishing indicative prices for each of the expenditure groups is a methodologically difficult task. The consumer price index data set comprises prices for distinct commodities. Prices are given for specific items rather than categories of commodities. It is also possible to obtain the actual weight of consumable products. The method of data collection enhances price accuracy because it is not affected by variations in quality. Nonetheless, it adds to the methodological complexity of determining group prices. Also, the welfare consequences of pricing increases are measured based on consumption rather

than production. Due to data availability, we only consider the consumption effect.

3. RESULTS AND DISCUSSIONS

Identifying the effect of prices on consumption of commodity bundles

Using iterated, feasible, generalised non-linear least-squares estimation, Stata 15.1 was utilised to estimate the QUAIDS model's parameters. Throughout the estimation process, the hypothetical constraints of adding up, symmetry and homogeneity were implemented. Using economic theory as a guide, this approach aims to manage residual heteroscedasticity. In the event that commodity group prices exhibit strong multicollinearity, this should only have an impact on the estimates' standard errors and produce less noteworthy findings. At the 5% level of significance, 68 out of the 88 estimated coefficients were found to be statistically significant. For the complete demand system, the estimated coefficients are revealed in Table 1.

The estimates of the QUAIDS model and the pertinent statistics are shown on Table 1. Firstly, the change in real income, $\frac{m}{\overline{m}_0(z)a(p)}$ (equation 20), holding comparative prices constant, will affect all commodity shares (increase or decrease). This is advised by the fact that all the β_i coefficients are statistically significant. Nonetheless, the direction (positive or negative) of the real income effect on commodity shares depends on the nature of the commodities of the sample. Precisely, a rise in the real income, other things being equal, will reduce the expenditure for food and non-alcoholic beverages; clothing and footwear; housing, water, electricity, and other energy sources that are characterised as 'necessities and all other commodity items as 'luxury' items. Secondly, the expenditure shares are, as anticipated, sensitive to price changes. However, a fundamental distinction must be made between the own and cross price effect. Own and cross price effects on expenditure shares depends on the nature of the commodities (i.e., complements vs substitutes). This issue is further discussed in the analysis that follows.

In determining whether the QUAIDS model is preferable to the AIDS model for the data set, the quadratic expenditure term is relevant. As is evident from Table 1, the quadratic expenditure terms (λ's) are all significant at 5% significance level. Consequently, a Wald's test was performed to determine whether the sum of the quadratic expenditure coefficients is significantly different from zero. This test statistic is 61.88 (p-value = 0.0000). As it cannot be accepted that the quadratic expenditure terms are equal to zero, the QUAIDS model is preferred to

the AIDS model for the data set. This means that South African total household expenditure is non-linear

For empirical analysis of indirect tax reforms, expenditure and own and cross-price elasticity of demand are of importance. It should be noted that the elasticities at the household level are required (and were calculated) for accurately estimating welfare consequences because of indirect tax reform. As it is not possible to provide the result for each household here, only the mean results (market demand) are reported here. Table 2 provides the expenditure elasticity for the expenditure categories, and Table 3 and Table 4 provide the uncompensated and compensated own and cross-price elasticity, respectively.

Table 1: QUAIDS: complete demand system coefficients estimated

	Food & non-alcoholic beverages	Alcohol, tobacco & narcotics	Clothing & footwear	Housing, water, electricity & other energy sources	Furnishing, equipment & maintenance	Health	Transport	Miscellaneous goods & services
Price: Food & non-alcoholic beverages	0.0408* (0.0101)*	0.0557* (0.0013)*	0.1694* (0.0155)*	0.0420 (0.0105)	0.1450* (0.0026)*	0.0541* (0.0085)*	0.0223 (0.0178)	0.4262* (0.0023)*
Price: Alcohol, tobacco & narcotics	- 0.0012 (0.0055)	- 0.0298* (0.0102)*	0.0456* (0.0052)*	0.0369* (0.0031)*	0.0376* (0.0042)*	- 0.0031* (0.0002)*	- 0.0460* (0.0004)	- 0.0548* (0.0006)*
Price: Clothing & footwear	- 0.0354* (0.0047)*	- 0.0084 (0.0053)	0.0235* (0.0044)*	- 0.0113* (0.0023)*	0.0010 (0.0006)	- 0.0123* (0.0019)*	0.0284* (0.0034)*	0.0078 (0.0003)
Price: Housing, water, electricity & other energy sources	0.0356* (0.0102)*	0.0156 (0.0142)	0.0146 (0.0085)	- 0.0102 (0.0233)	- 0.0085* (0.0003)*	- 0.0045* (0.0007)*	- 0.0379* (0.002)*	- 0.0163* (0.0004)*
Price: Furnishing, equipment & maintenance	- 0.0238* (0.0047)*	0.0065* (0.0033)*	- 0.0013 (0.0028)	- 0.0143* (0.0062)*	0.0286* (0.0037)*	0.0164* (0.0017)*	0.0102* (0.0025)*	- 0.0357* (0.0039)*
Price: Health	- 0.0219* (0.0030)*	- 0.0059* (0.002)*	- 0.0042* (0.0018)*	0.0133* (0.0039)*	0.0160* (0.0018)*	0.0038* (0.0015)*	0.0194* (0.0067)*	0.0163* (0.0017)*
Price: Transport	0.0219* (0.0092)*	0.0355* (0.0059)*	0.0251* (0.0052)*	-0.0897* (0.0115)*	- 0.0156* (0.0058)*	0.0162) (0.0039)*	- 0.2457 (0.0161)	0.0119* (0.0007)*
Price: Miscellaneous goods & services	- 0.0095* (0.0048)*	- 0.0121* (0.004)*	- 0.0139* (0.0033)*	0.0350* (0.0079)*	0.0038 (0.0030)	- 0.1092* (0.0018)*	- 0.0311* (0.0051)*	- 0.0234* (0.0045)*
Quadratic expenditure	- 00180* (0.0011)*	0.0004 (0.0003	- 0.0036* (0.0006)*	- 0.0062* (0.0010)*	0.0022* (0.0009)*	0.0073* (0.005)*	0.0029* (0.009)*	- 0.0057* (0.0009)*
Urban/rural (region)	0.0003 (0.0008)	- 0.0003 (0.0002)	0.0004 (0.004)	- 0.0011 (0.0009)	0.0003 (0.0007)	0.0007* (0.0003)*	- 0.0011 (0.0006)	0.0008 (0.0006)
Household size	- 0.0053* (0.0001)*	0.0004* (0.0001)*	0.0002* (0.0001)*	0.0037* (0.0001)*	- 0.0004* (0.0001)*	0.0005* (0.0001)*	0.0009* (0.0001)*	- 0.0003* 0.0001*

Note: (1) * indicates statistical significance at 5% level. (2) Estimated standard errors are in parentheses. (3) Prices are in log form

Source: Authors' calculations

Table 2 shows the expenditure elasticities for the commodity groups. As evident, all expenditure elasticities are positive and have nothing to do with inferior items in any of the commodity categories, statistically significant with elasticities between 0 and 1. Only health, furnishing, household equipment and routine household maintenance, transport and miscellaneous goods and services are luxury goods, and are income elastic (with $\mu_i > 1$). Even so, all expenditure groups are related with normal goods. 1% increase in income leads to 1.52% for furnishing, household equipment and routine maintenance, 1.2% for miscellaneous goods and services, 1.1% increase in demand for transport, 1.1% for health, 0.95% for clothing and footwear, 0.84% for food and non-alcoholic beverages, 0.67% for alcohol, cigarette, tobacco and narcotics, and of 0.46% for housing, water, electricity and other energy sources.

Miscellaneous goods and services include many commodity items which include luxury goods (e.g. watches, swimming pool equipment, toys, etc.). With regards to health, most medicines and hospital fees are subsidised by the government through public hospitals and only 32% of households in the survey reported that are affiliates of a medical aid fund. Nevertheless, expenditure on health items is questionable expenditure that is not subsidised by the government and not covered by medical aid. Further, most items that are usually considered to be luxury items are included in the miscellaneous goods and services. In terms of transport, 44% of the households said that they did not make use of public transport, of which 63% of those households mentioned that they made car payments (including petrol, oil, car services etc.), and these items are considered luxury items.

Table 2: Expenditure elasticities

	Expenditure elasticities
Food & non-alcoholic beverages	0.8369
Alcohol, cigarette, tobacco etc.	0.6654
Clothing & footwear	0.9511
Housing, water, electricity & other energy sources	0.4603
Furnishing, household equipment & maintenance	1.5210
Health	1.0663
Transport	1.0950
Miscellaneous goods & services	1.1718

Source: Authors' calculations

However, economic theory demands that all own price elasticities be negative and this condition is supported by the diagonal in Table 3. This indicates that, for expenditure categories in the total consumer demand system, if the price of a category rises, demand will fall. Both the compensated and uncompensated demand's own price elasticities are the right sign $(\varepsilon_{ij}<0; \varepsilon_{ij}^{c}<0)$. The compensated price elasticities are, as predicted, smaller in absolute values than the uncompensated price elasticities, and the majority of them are statistically significant $(|\varepsilon_{ij}|>|\varepsilon_{ij}^{c}|)$. Additionally, the own price elasticities seem reasonable in significance, with food and non-alcoholic beverages; clothing and footwear; and remarkably, housing, water, electricity and other energy sources, being relatively inelastic. Furnishing, household equipment and routine household maintenance; health, transport; and miscellaneous goods and services are comparatively unit elastic, and alcohol, cigarette, tobacco and narcotics is reasonably elastic.

Food and non-alcoholic beverages, clothing and footwear, as well as housing, water, electricity and other energy sources, appear to have inelastic demand, as these products might be claimed to be necessities. The finding that expenditure on housing, water, electricity and other energy sources is inelastic appears to imply that, despite price increases, when it comes to housing, water, electricity and other energy costs, consumers are either unwilling to cut back on their spending on these items or respond to them more slowly. This finding is corroborated by only two South African studies that found housing utilities to be price inelastic (Qeqe et al., 2022; Van Oordt, 2016). The result that health is quite elastic seems to support the conclusion that health is a luxury item, as earlier discussed.

The degree and arrangements of cross-price elasticity visible in the off-diagonal of Tables 3 and 4, which indicate complementary and substitution expenditure groups, appear reasonable. Several cross-price elasticities are near to zero, indicating that the two relevant expenditure categories are independent. The cross-price effect is weak. This is advised by the fact both compensated and uncompensated cross price elasticities of demand are less than one, except for transport and housing, water, electricity and other energy sources. A positive cross-price elasticity, as in the case of housing, water, electricity and other energy sources and food and non-alcoholic beverage, point out substitutes. Negative cross-price elasticities, as with food and non-alcoholic beverages and alcohol, cigarette, tobacco and narcotics, indicate complementarities (Varian, 2010).

Table 3: Uncompensated price elasticities

	Food & non-alcoholic beverages	Alcohol, cigarette, tobacco & narcotics	Clothing & footwear	Housing, water, electricity & other energy sources	Furnishing, household equipment & maintenance	Health	Transport	Miscellaneous goods & services
Food & non-alcoholic beverages	- 0.9608	- 0.0064	- 0.1140	0.1653	0.0065	- 0.0380	0.1127	- 0.0004
Alcohol, cigarette, tobacco etc.	- 0.0097	- 2.0005	- 0.2738	0.6132	0.2581	- 0.1650	1.2549	- 0.3426
Clothing & footwear	- 0.6823	- 0.1445	- 0.6218	0.2789	0.04361	- 0.0357	0.4450	- 0.2265
Housing, water, electricity & other energy sources	0.1795	0.1077	0.0858	- 0.9916	- 0.1340	0.057	- 0.7243	0.1590
Furnishing, household equipment & maintenance	0.1519	0.0988	0.0593	- 1.1052	- 1.1840	0.1280	- 0.1745	0.1610
Health	- 0.3119	- 0.1019	- 0.0466	0.1958	0.1564	- 1.0005	0.2472	- 0.2047
Transport	0.1974	0.2265	0.19100	- 0.7018	- 0.1532	0.0985	- 1.2088	0.2153
Miscellaneous goods & services	- 0.1184	- 0.07881	- 0.0986	0.1787	0.0308	- 0.0735	0.1700	- 1.1820

Note: The entry in row *i*, column *j* of the matrix, indicates the percentage change in the quantity of good *i* consumed for a 1% change in the price of good *j*.

Source: Authors' calculations

Table 4: Compensated price elasticities

	Food & non-alcoholic beverages	Alcohol, cigarette, tobacco & narcotics	Clothing & footwear	Housing, water, electricity & other energy sources	Furnishing, household equipment & maintenance	Health	Transport	Miscellaneous goods & services
Food & non-alcoholic beverages	- 0.6769	0.0184	- 0.0636	0.2798	0.0759	0.0071	0.2249	0.1340
Alcohol, cigarette, tobacco etc.	0.2160	- 1.9807	- 0.2338	0.7057	0.3133	- 0.1290	1.3441	- 0.2356
Clothing & footwear	- 0.3603	- 0.1162	- 0.5645	0.4040	0.1224	0.0156	0.5725	- 0.0736
Housing, water, electricity & other energy sources	0.6750	0.1513	0.1737	- 0.9886	- 0.0130	0.1363	- 0.5286	0.3938

	Food & non-alcoholic beverages	Alcohol, cigarette, tobacco & narcotics	Clothing & footwear	Housing, water, electricity & other energy sources	Furnishing, household equipment & maintenance	Health	Transport	Miscellaneous goods & services
Furnishing, household equipment & maintenance	0.3286	0.1143	0.0907	- 0.0328	- 0.7974	0.1562	- 0.1046	0.2448
Health	0.0497	- 0.0701	0.0175	0.3440	0.2448	- 0.9428	0.3901	- 0.0333
Transport	0.5689	0.2991	0.2569	- 0.5496	- 0.0624	0.1577	- 1.0620	0.3913
Miscellaneous goods & services	0.2790	- 0.0438	- 0.0280	0.3416	0.1280	- 0.0101	0.3271	- 0.9936

Note: The entry in row *i*, column *j* of the matrix, indicates the percentage change in the quantity of good *i* consumed for a 1% change in the price of good.

Source: Authors' calculations

Measuring the effect of VAT increase on households' welfare

In South Africa, satisfying necessities for food products and non-alcoholic refreshments accounts for more than 30% of household budgets, notwithstanding a recent downward trend in the share of food expenditures across income levels and geographic regions (Table 5). Engel's law suggests that this decline represents a rise in household welfare. Chai and Stepanova (2023) support this proclamation. Urban areas have a similar share of food and non-alcoholic refreshments' expenditure as rural areas, and lower for rural dwellers than for urban in the case of alcohol beverages, cigarettes, tobacco and narcotics commodity group. Because of the lower income elasticity of demand for food products and non-alcoholic refreshments than for non-food items, the expenditure shares on this commodity group decline as income rises, in contrast to the increase in overall commodity group expenditure. Changes in price for food products and non-alcoholic refreshments also have an impact on the share of expenditure that goes toward them, as Korir et al. (2018) and Faharuddin et al. (2022) observed.

According to Rossouw (2022), South Africa's average food price inflation has increased dramatically since 2008. Because of the significant inflation of food prices, this caused an appreciation in the proportions of food expenditures. It makes a compelling case for the necessity of keeping food costs low in order to prevent a drop in household welfare and a rise in the poverty rate. In comparison to urban areas, the expenditure share for miscellaneous goods and services is likewise higher in rural areas, as found by Chikobola and Edriss (2016) and Kelly et al. (2018). This is because the commodity group includes many goods and services. For example, personal care products (bath products, cleaning detergents,

feeding bottles, etc.), childcare services and miscellaneous concessions (toilets, seats) to say the least. Many may consider the above-mentioned commodity items to be essential, of which a typical consumer may purchase second along with food consumption.

Table 5: Average expenditure shares by area and poverty status

	Area		Poverty Status		Entire sample
	Rural	Urban	Poor	Non-poor	
Food & non-alcoholic refreshments	0.3406424	0.3383024	0.3607394	0.324512	0.3392427
Alcohol, cigarette, tobacco & narcotics	0.0292129	0.0302129	0.0367696	0.0250521	0.0298110
Clothing & footwear	0.0611864	0.0595410	0.0603388	0.0601088	0.0602022
Housing, water, electricity & other energy sources	0.1357581	0.1411745	0.1061746	0.1614457	0.1389979
Furnishing, household equipment & maintenance	0.0837987	0.0823129	0.1065816	0.066721	0.082910
Health	0.0553362	0.0531719	0.0546935	0.535958	0.0540416
Transport	0.1311016	0.1360311	0.1313532	0.1358947	0.1340502
Miscellaneous goods & services	0.1629638	0.1592532	0.1433492	0.1726408	0.167443

Source: Authors' calculations

Expenditure for furnishing, household equipment and maintenance; health; clothing and footwear is also quite larger. Kelly et al. (2018) support this assertion in their study on "Inflation in a time of inequality: Assessing the Relevance of Cost-of-Living Measures for the Poor". Whereas, for housing, water, electricity and other energy sources; alcohol, cigarette, tobacco and narcotics, and transport, expenditure is greater in urban areas related to rural areas.

Table 6 shows the price and expenditure elasticities that follow. Overall, urban areas have less elasticity in their expenditures for food products and non-alcoholic refreshments than rural regions, as observed by Faharuddin et al. (2022). It is clear that, even in rural homes, the consumption of these goods is still seen as a welfare symbol, meaning that when income levels rise, rural residents will continue to consume more commodities. With the exception of four commodity groups with higher prices - household contents and maintenance, health, transportation, and miscellaneous products and services - the majority of commodity sets have spending elasticity less than 1. Since every spending elasticity is positive, more money would be spent on every set of commodities if income increased. Only four commodity groups, however, had considerably

greater disparities in expenditure elasticity. Household contents and maintenance and miscellaneous products and services are luxury goods, with elasticities greater than 1.2.

Table 6: Expenditure and price elasticity by urban-rural

Commodity groups	Expenditure elasticities			Compensated price elasticities			Uncompensated price elasticities		
	Rural	Urban	Overall	Rural	Urban	Overall	Rural	Urban	Overall
Food & non-alcohol beverages	0.8434	0.8326	0.8369	-0.7333	-0.6499	-0.6769	-0.9994	-0.9324	-0.9608
Alcohol, cigarette, tobacco & narcotics	0.7065	0.6372	0.6654	-2.0750	-1.9355	.1.9807	-2.0961	-1.9545	-2.0005
Clothing & footwear	0.9686	0.9412	0.9511	-0.5406	-0.5789	-0.5645	-0.5989	-0.6356	-0.6218
Housing, water, electricity & other energy sources	0.4367	0.4742	0.4603	-0.9791	-0.9957	-0.9886	-0.9816	-0.9978	-0.9916
Furnishing, household equipment & maintenance	1.5151	1.5304	1.5210	-0.7643	-0.8243	-0.7974	-1.0495	-1.1694	-1.1840
Health	1.0845	1.0509	1.0663	-0.9325	-0.9433	-0.9428	-0.9911	-1.0001	-1.0005
Transport	1.0824	1.1024	1.0950	-1.1641	-0.9823	-1.0620	-1.3091	-1.1201	-1.2088
Miscellaneous goods & services	1.1721	1.1721	1.1718	-0.9972	-0.9926	-0.9936	-1.1857	-1.1810	-1.1820

Source: Authors' calculations

In terms of own-price elasticity, demand theory is supported by the fact that every price elasticity coefficient is negative, which states that demand for food decreases as price increases. Only four spending groups are elastic in rural regions, with elasticity less than one, notably food products and non-alcoholic refreshments, apparel and footwear, housing utilities, and health. Only two groups, however, reveal a significant variation between urban and rural locations (food products and non-alcoholic refreshments and apparel and footwear). Apparel and footwear are price inelastic, which are similar as reported in Li et al. (2023), Zehra et al. (2023) and Zhang and Zhang (2023).

Drawing on the family budget share, actual proportional change in price and expected responses of consumers, we calculate the welfare costs associated with changes in commodity prices in South Africa. This subsection aims to measure the "dynamic" household welfare effect, which takes into account both consumption responses and (static) first order effects in consumption. We further provide estimates using a first-order approximation to the changes in commodity prices for comparison's sake, assuming households are unable to substitutes and maintaining constant consumer behavioral reactions. To achieve that, we compute

the welfare effect of the observed shift in commodity prices using the estimated Hicksian elasticities. In 2018 for the time between 2017/18 and 2018/19, the CV determines how much we would have to provide customers to make them feel as good as they did before to the price adjustment (VAT increase). Table 7 presents welfare effects. First-order effects are shown in Column 2 and are calculated using equation (17). The dynamic effects are thus measured in Columns 3 and 4, which take into account both first-order and consumer response effects in consumption as a share of household food expenditure and total household expenditure in 2017–18, respectively.

Depending on the size of the rise in prices for commodity groups and the percentage of these shares of expenditures for item groups, the effect of growing commodity prices on welfare of households varies. When costs increase and a larger portion of spending is devoted to commodity groups, the effect on the reduction in household welfare grows. Therefore, the price increases for food products and non-alcoholic refreshments; alcoholic beverages, tobacco and narcotics; housing utilities; and other miscellaneous items and services have the greatest effect on household welfare. Except in the case of miscellaneous goods and services, three of the four groups had lower income elasticities in addition to larger expenditure shares.

The rise in prices of these commodity sets causes a decline in welfare by 3.64%, 1.67%, 2.01% and 5.03%, respectively. In order to compensate for changes in the cost of food and non-alcoholic beverages, households with lower incomes will need to spend more. This is supported by the findings of Wassiuw (2017) in Ghana. The investigation only considered the impact of price changes on consumption, not household output, which may explain why the rural poor are disproportionately affected. Recent estimates (Bila, 2021) indicate that rural areas have a high poverty headcount ratio in the region of approximately 81.3%, compared to urban areas where it hovers at 40.7%. This raises concerns for food security and poverty reduction initiatives. Likewise, urban households will spend more on alcoholic beverages, cigarette, tobacco and narcotics. This is simply because these commodity items are consumed more in urban areas than in rural regions, as Peer et al. (2013) observed on tobacco and Pengpid et al. (2021) observed on alcohol and drugs use.

Even though the government provides affordable housing for most South Africans, the nation's impoverished and needy continue to face severe housing issues, such as corruption, mismanagement of housing projects and unemployment to mention a few (Manomano et al., 2016). More than 80% of South African households, according to Statistics-South-Africa (2023), reside

in formal housing, the majority of which receive electricity and water from the municipality. These families, including those in informal housing, use other energy sources like gas and paraffin. As was previously said, rising prices and ongoing high levels of inequality, poverty and unemployment will make it harder for low-income families to maintain their homes since they will have to pay more for housing, water, electricity and other energy sources. In terms of miscellaneous goods and services, most of the items are consumed by well off families, even so, the commodity group includes expenditure items which one may consider a necessity such as bath soaps and cleaning detergents (refer to (United-Nations, 2018)).

Table 7: Compensating Variation (%)

Commodity group	First order effects as a proportion of household expenditure	Second order effects as a proportion of household expenditure	Second order effects as a proportion of total household expenditure
Food & non-alcoholic refreshments	3.097	4.291	3.638
Alcohol, cigarette, tobacco & narcotics	1.695	1.874	1.667
Clothing & footwear	0.756	0.501	0.640
Housing, water & other energy sources	1.820	2.241	2.011
Furnishing, household equipment & maintenance	1.008	0.922	0.969
Health	0.771	1.037	0.892
Transport	0.154	0.215	0.181
Miscellaneous goods & services	5.984	3.887	5.025

Source: Authors' calculations

The larger the price rise, the bigger the proportion of CV reduction. The slightest effect on households' welfare is the price rise of household contents and maintenance; health; apparel and footwear; and transportation - with a drop in welfare by 0.97%, 0.89%, 0.64% and 0.18%. Household contents costs are increasing but not at an extreme rate in South Africa (Statista, 2024b). Similarly, the Consumer Price Index (CPI) for apparel and footwear has exhibited a modest growth (Statista, 2024a). Also, in the views of, Statistics-South-Africa (2022b), Statistics-South-Africa (2024), Wolhuter (2022) and Kelly (2025), the trajectory of transport costs in South Africa has been uneven; some measures point to a slowdown in inflation, while others point to ongoing pressures. Fuel prices, a major factor in transportation expenses, have varied over time, rising and falling at different times. However, healthcare expenses typically rise at a rate exceeding normal inflation, with medical aid rates frequently surpassing the

Consumer Price Index (CPI) (Statistics-South-Africa, 2019). These commodity groups have the least impact on welfare, and because South Africa is a welfare state, families will continue to pay more for them. Therefore, those who are poor and vulnerable will bear the brunt of the consequences.

5. CONCLUSIONS

Based on the South African VAT rise, this study calculated the welfare effects of changes in commodity prices. We determined the expenditure, own-price and cross-price demand elasticities for each of the eight commodity groups that South African families consume using the QUAIDS model. The results showed that the demand for food and non-alcoholic refreshments, housing utilities, and apparel and footwear, in South Africa are inelastic. Whereas, the demand for alcohol, cigarettes, tobacco and narcotics is elastic, as is the demand for furnishing, household contents and maintenance, health, transportation, and miscellaneous goods and services. Furthermore, disadvantaged households are typically the ones most impacted by price increases. The outcomes of this paper revealed that South African households suffered welfare losses resulting from commodity price changes. These findings are significant because it will be challenging to create effective policies without a complete grasp of the many ways in which various household types in various locations are impacted by changes in commodity prices and how responsive they are. With this knowledge, decision-makers in developing nations like South Africa will be able to enact more targeted and effective measures to combat poverty and inequality. Nevertheless, data limitations continue to be a significant issue, despite the fact that this research is crucial for developing nations.

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Conflict of interests

The authors declare there is no conflict of interest.

REFERENCES

Ackah, C., & Appleton, S. (2007). *Food price changes and consumer welfare in Ghana in the 1990s*. https://hdl.handle.net/10419/80310

Attanasio, O., Di Maro, V., Lechene, V., & Phillips, D. (2013). Welfare consequences of food prices increases: Evidence from rural Mexico. *Journal of Development Economics*, *104*, 136-151. https://doi.org/10.1016/j.jdeveco.2013.03.009

Banks, J., Blundell, R., & Lewbel, A. (1997). Quadratic Engel curves and consumer demand. *Review of Econometrics and statistics*, *79*(4), 527-539. https://www.jstor.org/stable/pdf/2951405.pdf

Barnett, W. A., & Seck, O. (2008). Rotterdam model versus almost ideal demand system: will the best specification please stand up? *Journal of Applied Econometrics*, *23*(6), 795-824. https://doi.org/10.1002/jae.1009

Bila, S. N. (2021). *Determinants of subjective poverty in rural and urban areas of South Africa*. University of Johannesburg (South Africa). https://www.proquest.com/docview/2800161480?pq-origsite=gscholar&fromopenview=true&sourcetype=Dissertations%20&%20Theses

Blundell, R., & Robin, J.-M. (2000). Latent seperability: grouping goods without weak separanbility. *Econometrica 68*(1), 53-84. https://doi.org/10.1111/1468-0262.00093

Bopape, L., & Myers, R. (2007). Analysis of household demand for food in South Africa: Model selection, expenditure endogeneity, and the influence of socio-demographic effects. *Proceedings of the African Econometrics Society Annual Conference*, https://www.researchgate.net/publication/253215619_Analysis_of_Household_Demand_for_Food_in_South_Africa_Model_Selection_Expenditure_Endogeneity_and_the_Influence_of_Socio-_Demographic_Effects

Chai, A., & Stepanova, E. (2023). Engel curves, spending diversity and welfare measurement. *Research Handbook on Measuring Poverty and Deprivation*, 544-552. https://doi.org/10.4337/9781800883451.00067

Chikobola, M. M., & Edriss, A.-K. (2016). Estimation of rural-urban expenditure and elasticities of food items in Zambia: Evidence from Living Conditions Monitoring Survey. *Modern Economy*, *7*(5), 567-574. http://dx.doi.org/10.4236/me.2016.75062

Deaton, A. (1987). Estimation of own-and cross-price elasticities from household survey data. *Journal of Econometrics*, *36*(1-2), 7-30. https://doi.org/10.1016/0304-4076(87)90041-8

Deaton, A. (1988). Quality, quantity, and spatial variation of price. *The American Economic Review*, 418-430. https://www.jstor.org/stable/1809142

Deaton, A. (1990). Price elasticities from survey data: extensions and Indonesian results. *Journal of econometrics*, *44*(3), 281-309. https://doi.org/10.1016/0304-4076(90)90060-7

Deaton, A. (1997). *The analysis of household surveys: a microeconometric approach to development policy*. The World Bank. https://books.google.co.za/books?hl=en&lr=&id=Mfe8ukMh_v4C&oi=fnd&pg=PA1&dq=he+analysis

+of+household+surveys:+a+microeconometric+approach+to+development+policy&ots=YoMnhENbfG&sig=vNa1g7WgqOBByfwDinxyg-zMlsW0&redir_esc=y#v=onepage&q=he%20analysis%20of%20household%20surveys%3A%20a%20microeconometric%20approach%20to%20development%20policy&f=false

Deaton, A., & Muellbauer, J. (1980). An almost ideal demand system. *The American economic review*, *70*(3), 312-326. https://www.aeaweb.org/aer/top20/70.3.312-326.pdf

Deaton, A., & Muellbauer, J. (1980). *Economics and consumer behavior*. Cambridge university press. https://books.google.co.za/books?hl=en&lr=&id=B81RYQsx2l0C&oi=fnd&pg=PR8&dq=Economics+and+consumer+behavior&ots=m1MDCx-E-I&sig=N-WAtI6mN5_yMQimbwWXHvYROmY&redir_esc=y#v=onepage&q=Economics%20and%20consumer%20behavior&f=false

Erero, J. L. (2015). Effects of increases in value added tax: A dynamic CGE approach. *Economic Research Southern Africa*, *558*. http://dx.doi.org/10.13140/RG.2.2.34280.26885

Faharuddin, F., Yamin, M., Mulyana, A., & Yunita, Y. (2022). Impact of food price increases on poverty in Indonesia: empirical evidence from cross-sectional data. *Journal of Asian Business and Economic Studies*(ahead-of-print). http://dx.doi.org/10.1108/JABES-06-2021-0066

Friedman, J., & Levinsohn, J. (2002). The distributional impacts of Indonesia's financial crisis on household welfare: A "rapid response" methodology. *The World Bank Economic Review*, *16*(3), 397-423. https://www.jstor.org/stable/pdf/3990193.pdf

Hicks, J. R. (1936). Keynes' Theory of Employment, Interest and Money. *The Economic Journal*, *46*(182), 238-253. https://doi.org/10.2307/2549064

Holt, M. T. (2002). Inverse demand systems and choice of functional form. *European Economic Review*, *46*(1), 117-142. https://doi.org/10.1016/S0014-2921(00)00088-X

Industrial-Development-Corporation. (2016). *Economic Trends: Key trends in the South African economy*. https://www.idc.co.za/wp-content/uploads/2018/11/RI-publication-Keytrends-in-SA-economy_March2016.pdf

Industrial-Development-Corporation. (2018). *Economic Trends: Key trends in the South African economy*. https://www.idc.co.za/wp-content/uploads/2018/11/IDC-RI-publication-Key-trends-in-the-South-African-economy-29-March.pdf

Industrial-Development-Corporation. (2019). *Economic Trends: Key trends in the South African Economy*. https://www.idc.co.za/wp-content/uploads/2019/04/IDC-RI-publication-Key-trends-in-South-African-economy-29-March-2019.pdf

Industrial-Development-Corporation. (2023). *Economic Trends: Key trends in the South African economy.* Industrial Development Corporation https://www.idc.co.za/wp-content/uploads/2023/04/IDC-RI-publication-Key-trends-in-the-South-African-economy-April-20234.pdf

Kelly, G. (2025). Fuel price increase – what it means from a road freight logistics perspective. *African Business Quaterly.* https://www.abizq.co.za/fuel-price-increase-what-it-

means-from-a-road-freight-logistics-perspective/#:~:text=Whether%20we%20like%20it%20or,in%20the%20last%20few%20months.

Kelly, P., Ruch, W., Ruch, F., & Matlhatsi, R. (2018). *Inflation in a time of inequality: Assessing the relevance of cost of living measures for the poor.* Paper prepared for the Meeting of the Group of Experts on Consumer Price Indices,

Korir, L., Rizov, M., & Ruto, E. (2018). *Analysis of household food demand and its implications on food security in Kenya: an application of QUAIDS model*. http://dx.doi.org/10.22004/ag.econ.273474

Lewbel, A. (1996). Aggregation without separability: a generalized composite commodity theorem. *The American Economic Review*, *86*(3), 524-543. https://www.jstor.org/stable/2118210

Leyaro, V., Morrissey, O., & Owens, T. (2010). *Food price changes and consumer welfare in Tanzania 1991-2007*. https://www.econstor.eu/obitstream/10419/65468/1/643905847.pdf

Li, L., Bai, J., & Zhu, Q. (2023). The effect of rising food prices on nutrient intake among rural–urban migrants in China. *China Agricultural Economic Review*, *15*(3), 642-665. https://doi.org/10.1108/CAER-04-2022-0084

Manomano, T., Tanga, P. T., & Tanyi, P. (2016). Housing problems and programs in South Africa: A literature review. *Journal of Sociology and Social Anthropology*, *7*(2), 111-117. https://d1wqtxts1xzle7.cloudfront.net/58916695/HousingProblemandProgramsinS.Africa-Literaturereview-JSSA2016vol.72pp.111-117.pdf?1738382726=&response-content-disposition=inline%3B+filename%3DHousing_Problems_and_Programs_in_South_A.pdf&Expires=1748330903&Signature=Rsf0IMsV8dlTG7u-O~bcJlg40TawWsBLHor8rSRscU0OLcnYtliDqzfH6W4Hb-lzFNXnFAUAetL~0~T~tRadHoAkoZ8YuCkPjF1VdDbNb4L3OTE42blCvcIHbbA4RSIg-JbFZ1M4kGxo6rrk8CMXn9-DwElhkzCAXJo19ihF2xM64ejT9Y8OGKlhiEiKyMXlt1oWM~8QjniyitV8fGczT4OaYhQmEoEUErD0wCilRlZNmAsgRgLLvps0-PyKg7nPvu7-QUQRqAeIQUiog-qw5Qj15FMyBgX~wfPFilsVgx9zzt2OKxrA8RarW2w0A~MWaG~MQWT2CSQQ6gU9W-rEWA__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA

Minot, N., & Goletti, F. (2000). *Rice market liberalization and poverty in Viet Nam* (Vol. 114). Intl Food Policy Res Inst. https://core.ac.uk/download/pdf/6388402.pdf

National-Treasury. (2018). *Recommendations on Zero Ratings in the Value-Added Tax System*. National Treasury http://www.treasury.gov.za/comm_media/press/2018/2018081001%20VAT%20Panel%20Final%20Report.pdf

Niimi, Y. (2005). *An analysis of household responses to price shocks in Vietnam: Can unit values substitute for market prices.* https://core.ac.uk/download/pdf/6301564.pdf

Peer, N., Bradshaw, D., Laubscher, R., Steyn, N., & Steyn, K. (2013). Urban–rural and gender differences in tobacco and alcohol use, diet and physical activity among young black South Africans between 1998 and 2003. *Global health action*, *6*(1), 19216. https://doi.org/10.3402/gha.v6i0.19216

Pengpid, S., Peltzer, K., & Ramlagan, S. (2021). Prevalence and correlates of hazardous, harmful or dependent alcohol use and drug use amongst persons 15 years and

older in South Africa: Results of a national survey in 2017. *African Journal of Primary Health Care & Family Medicine*, *13*(1), 2847. https://journals.co.za/doi/epdf/10.4102/phcfm.v13i1.2847

Poi, B. P. (2012). Easy demand system estimation with quaids. *The Stata Journal*, *12*(3), 433-446. https://journals.sagepub.com/doi/pdf/10.1177/1536867X1201200306

Polack, R. A., & Wales, T. J. (1981). Demographic variables in demand analysis. *Econometrica: Journal of the Econometric Society*, *49*(6), 1533-1551. https://doi.org/10.2307/1911416

Pons, N. (2011). Food and prices in India: Impact of rising food prices on welfare. *Centre De Sciences Humaines, Delhi, India*. http://www.isid.ac.in/~pu/conference/dec_11_conf/Papers/NathaliePons.pdf

Qeqe, B., Kapingura, F., & Mgxekwa, B. (2022). The Relationship between Electricity Prices and Household Welfare in South Africa. *Energies*, *15*(20), 7794. https://doi.org/10.3390/en15207794

Ray, R. (1983). Measuring the costs of children: an alternative approach. *Journal of Public Economics*, *22*(1), 89-102. https://doi.org/10.1016/0047-2727(83)90058-0

Roos, E. L., Horridge, J. M., Van Heerden, J. H., Adams, P. D., Bohlmann, H. R., Kobe, K. K., & Vumbukani-Lepolesa, B. (2020). National and Regional Impacts of an Increase in Value-Added Tax: A CGE Analysis for South Africa. *South African Journal of Economics*, *88*(1), 90-120. https://doi.org/10.1111/saje.12240

Rossouw, J. (2022). *Rising food prices: a close look at inflation in South Africa*. https://www.wits.ac.za/news/latest-news/opinion/2022/2022-06/rising-food-prices-a-close-look-at-inflation-in-south-africa.html

Sekwati, L., & Malema, B. W. (2011). Potential impact of the increase in VAT on poor households in Botswana. *International journal of economics and research (online)*. https://www.researchgate.net/publication/50315657_POTENTIAL_IMPACT_OF_THE_INCREASE_IN_VAT_ON_POOR_HOUSEHOLDS_IN_BOTSWANA

Shonkwiler, J. S., & Yen, S. T. (1999). Two-Step Estimation of a Censored System of Equations. *American Journal of Agricultural Economics*, *81*(4), 972-982. https://doi.org/10.2307/1244339

Sola, O. (2013). Demand for food in Ondo state, Nigeria: Using quadratic almost ideal demand system. *Joournal of Business Management and Economics*, *4*(1), 1-19. https://jsd-africa.com/Jsda/Vol15No6-Fall2013B/PDF/Demand%20for%20Food%20in%20Ondo%20State.Sola%20Olorunefemi.pdf

Statista. (2024a). *Consumer price index (CPI) of clothing and footwear in South Africa from January 2022 to July 2024*.

Statista. (2024b). *Home Décor: market data & analysis*. https://www.statista.com/outlook/cmo/furniture/home-decor/south-africa

Statistics-South-Africa. (2017). *Consumer Price Index: The South African CPI Sources and Methods Manual*. Statistics South Africa: Statistics South Africa. https://www.statssa.gov.za/cpi/documents/The_South_African_CPI_sources_and_methods_26Feb13.pdf

Statistics-South-Africa. (2019). *Medical aid and transport costs nudge inflation higher*. Statistics South Africa: Statistics South Africa. https://www.statssa.gov.za/?p=11999#:~:text=Stats%20SA%20surveys%20health%20insurance,on%2Dyear%20in%20February%202019.

Statistics-South-Africa. (2022a). *Quarterly Labour Force Survey (QLFS) Q4:2022*. Retrieved from https://www.statssa.gov.za/publications/P0211/Presentation%20QLFS%20Q4%202022.pdf

Statistics-South-Africa. (2022b). *Transport costs continue to drive inflation higher*. Statistics South Africa Retrieved from https://www.statssa.gov.za/?p=15341

Statistics-South-Africa. (2023). *The state of South African households in 2023*. Statistics South Africa: Statistics South Africa. https://www.statssa.gov.za/?p=17283#:~:text=Although%20the%20proportion%20of%20households,73%2C5%25%20in%202002.

Statistics-South-Africa. (2024). *Consumer inflation retreats further in September*. Statistics South Africa Retrieved from https://www.statssa.gov.za/?p=17719#:~:text=Transport%20inflation%20continues%20to%20ease&text=A%20litre%20of%20inland%2095,2023%20(R21%2C68).&text=Price%20increases%20for%20vehicles%20have,%2C4%25%20in%20September%202023.

Taylor, C. D. (2014). *An almost ideal demand system analysis of orange and grapefruit beverage consumption in the United States* Clemson University]. https://nwulib.idm.oclc.org/login?url=https://www.proquest.com/dissertations-theses/almost-ideal-demand-system-analysis-orange/docview/1615864745/se-2?accountid=12865

United-Nations. (2018). *Classification of Individual Consumption According to Purpose (COICOP) 2018*. United Nations: United Nations. https://unstats.un.org/unsd/classifications/unsdclassifications/COICOP_2018_-_pre-edited_white_cover_version_-_2018-12-26.pdf

Van Oordt, M. L. (2016). A nutritional goods and a complete consumer demand system estimation for South Africa using actual prices data *South African Journal of Economic and Management Sciences*, *19*(4), 615-629. https://www.scielo.org.za/pdf/sajems/v19n4/10.pdf

Varian, H. R. (2010). *Intermediate Microeconomics*. W.W Norton & Company. https://dn721907.ca.archive.org/0/items/hal-r.-varian-intermediate-microeconomics-a-modern-approach-8th-edition-w.-w.-norton-co.-2010/Hal%20R.%20Varian%20-%20Intermediate%20Microeconomics_%20A%20Modern%20Approach%2C%208th%20Edition%20-W.W.%20Norton%20%26%20Co.%20%282010%29.pdf

Vu, L., & Paul, G. (2011). Impact of rising food prices on poverty and welfare in Vietnam. *Journal of Agricultural and Resource Economics*, *36*(1), 14-27. http://depocenwp.org/upload/pubs/VuHoangLinh/IMPACTS%20OF%20RISING%20FOOD%20PRICES%20ON%20POVERTY%20AND%20WELFARE%20IN%20VIETNAM_DEPOCENWP.pdf

Wassiuw, A. R. (2017). *Price change and households' welfare in Ghana (1991-2013)* University of Nottingham]. https://eprints.nottingham.ac.uk/47400/1/Price%20Change%20and%20Households%27%20Welfare%20in%20Ghana%20%281991-2013%29.pdf

Wolhuter, A. (2022). *Note on supply chain pressures in South Africa*. South African reserve Bank Retrieved from https://www.resbank.co.za/content/dam/sarb/publications/quarterly-bulletins/articles-and-notes/2022/03Note%20on%20supply%20chain%20pressures%20in%20South%20Africa.pdf

World-Bank-Group. (2018). *Overcoming poverty and inequality in South Africa: An assessment of drivers, constraints and opportunities*. https://documents1.worldbank.org/curated/en/530481521735906534/pdf/Overcoming-Poverty-and-Inequality-in-South-Africa-An-Assessment-of-Drivers-Constraints-and-Opportunities.pdf

Zehra, N., Javed, S., & Fatima, A. (2023). HOUSEHOLD FOOD AND NON-FOOD CONSUMPTION BEHAVIOUR IN PAKISTAN. *Pakistan Journal of International Affairs*, *6*(2). https://doi.org/10.52337/pjia.v6i2.769

Zhang, Y., & Zhang, Q. (2023). Income Disparity, Consumption Patterns, and Trends of International Consumption Center City Construction, Based on a Test of China's Consumer Market. *Sustainability*, *15*(4), 2862. https://doi.org/10.3390/su15042862

УТИЦАЈ ПОВЕЋАЊА ПРЕЗА НА ДОДАТУ ВРИЈЕДНОСТ НА ДОБРОБИТ ДОМАЋИНСТАВА У ЈУЖНОАФРИЧКОЈ РЕПУБЛИЦИ

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САЖЕТАК

Порез на додату вриједност (ПДВ) у Јужној Африци повећан је са 14% на 15% 1. априла 2018. године због хитне потребе да се избјегну буџетски дефицити. Повећање ПДВ-а увијек доводи до раста цијена, што има негативан утицај на куповну моћ потрошача. Ова студија је процијенила ефекте промјене цијена робе након повећања ПДВ-а на добробит јужноафричких породица. Подаци су коришћени из Националне динамичке анкете прихода 2018. године и Јужноафричких индекса потрошачких цијена (2017/18. и 2018/19). Еластичности цијена добијене су моделом квадратичног готово идеалног система потражње (Quadratic Almost Ideal Demand System Model), а затим је уз помоћ еластичности цијена, израчунат утицај флуктуација цијена робе

у смислу компензационе варијације (Compensating Variation). Закључци студије пружају важну основу за емпиријско испитивање са циљем прецизног утврђивања утицаја на добробит. Рад препоручује да уместо једнаког ПДВ стандарда, луксузна добра треба да буду подложна већој стопи ПДВ-а, као на примјер скупи ручни сатови, јахте и аутомобили. Због великог удјела луксузне робе која се увози, домаћа потражња можда неће бити негативно погођена, а платни биланс може чак и благо да се побољша. Такође, студија подржава проширење списка производа са нултом стопом опорезивања како би се укључили производи које сиромашније становништво чешће купује, као што су све врсте хљеба, сапуни, свијеће и предмети повезани са образовањем (као што су школске униформе). Поред тога, ови налази су дио ширег истраживања о квантитативним процјенама алтернативних политика које треба да помогну у реформисању ПДВ-а у земљи.

Кључне ријечи: *порез на додату вриједност, цијене робе, добробит домаћинстава, Јужноафричка Република*

Прегледни научни радови
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DRIVERS OF NATURAL GAS PRICES IN EUROPEAN UNION

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ABSTRACT

Natural gas is a key source of energy and an important industrial input in electricity generation. The three gas directives from the beginning of the 21st century liberalised the European gas market. They incentivised a switch from Oil Price Indexing to a Gas-on-Gas price-setting mechanism, which made the deregulated market an interesting object of research. The drivers of natural gas prices in the European market are examinee. A VAR model with exogenous variable (VARX) is used to estimate the effects of chosen factors. The impulse-response function shows that in the short run, the European gas market is sensitive to imports of liquid natural gas and gas storage, whereas in the long run, it is highly dependent on coal, with air temperature and oil prices playing a negligible role. Forecast error variance decomposition results indicate the relationship between natural gas and coal prices in Europe. Cumulatively, approximately 64% of natural gas price variation is explained by variations in coal prices, gas storage and liquid natural gas imports, with coal prices being the single most important driver of natural gas prices, contributing to 35% of price variation.

1. INTRODUCTION

This paper aims to explore the drivers of natural gas prices in the European Union (EU) market. Apart from being a source of heating for residential and commercial properties, natural gas is an important input for the industry (has a more positive environmental footprint compared to other traditional energy sources and positively affects the competitiveness of the economy) and for

producing electricity, especially when filling the gap of energy supply that stems from sometimes unreliable renewables. Due to this, understanding the factors that drive the price of natural gas is of great importance both to policymakers and to microeconomic agents, i.e. households and companies.

There is a significant gap in the literature that analyses the factors that affect how natural gas prices are formed in the EU. The reason lies in the complex modeling of the European market, whose natural gas supply comes from two sources: pipelines imports and liquefied natural gas (LNG) imports, while domestic production is almost negligible accounting for only 18% of EU's gas natural gas consumption in the 2016-2022 period. Another challenge in modeling this market comes from the liberalisation processes that happened in the last two decades. European natural gas markets experienced gradual liberalisation at different pace across countries. The liberalisation of the gas sector in continental Europe has led to the creation of several gas hubs with transparent prices. The first gas directive, adopted in 1998, opened the market and paved the way for easier transit, distribution, supply and storage of gas. The second directive (2003) made a distinction between gas transport and supply. The third directive in 2009 laid the foundation for the efficient functioning of the natural gas market, including subsidising the founding of new gas hubs. Opolska & Jakubczyk (2013) find that European markets with more concentrated gas import structures and higher import dependence (especially on Russia) tended to implement market reforms later, while countries with competitive market structures and higher initial gas prices liberalised faster.

Price setting in liberalised natural gas markets is complex due to numerous factors influencing supply and demand, such as weather conditions, the business cycle and international trade developments. Three gas directives, together with global developments in the gas market at the end of 2010 (global financial crisis, shale gas revolution, Fukushima nuclear power plant incident, oil prices decrease) led to a gradual but significant shift from the Oil Price Indexation (OPI) to Gas-on-Gas (GOG) gas price forming mechanism. All buyers required radical negotiations of contracts for gas imports that fixed the gas prices on oil prices, due to the big risk of prices significantly diverging from realistic market conditions. The separation of two pricing models initiated a revision of European gas contracts, while the indexation of oil was largely abandoned (Lorefice, 2017). From 2005 to 2020, the share of GoG contracts grew from 15 to 80% in total gas consumption, while the share of OPI contracts decreased from 78 to 20% (International Gas Union [IGU], 2021). This differentiation of prices in Europe is mostly associated with the development of liquid spot markets that incentivise

competition in GoG, while simultaneously contributing to a gradual, but stable decrease of OPI.

The European Union influences and transforms its gas market through energy policy, allowing it to enhance resilience by investing and developing infrastructure. Baltensperger et al. (2017) analyse effects of planned infrastructure expansions on consumption, prices and social welfare in the EU's gas markets and highlight how new gas sources and infrastructure projects can decrease prices, increase social welfare and reduce suppliers' market power.

Natural gas trading hubs gained rapid importance following liberalisation. Trade in the National Balancing Point (NBP) gas hubs in the United Kingdom and Title Transfer Facility (TTF) in the Netherlands have become more important due to Brexit insecurity and declining endogenous gas production in the UK (Heather, 2012). In 2016 TTF became a hub with the highest trade volume in Europe and served as the primary hedging and general trade point of European gas subjects. The annual trade volume in TTF in 2022 is estimated at 63% of the total European trade (IGU, 2023).

Unpredictable disruptions in gas supply can have significant repercussions, especially in continental Europe, which was exposed to interruptions during the Russia-Ukraine dispute on gas transport in 2009, production interruption in Libya in 2011, as well as the political decision to decrease dependence on Russian gas after the beginning of the war in Ukraine. Carvalho et al. (2014) investigate the vulnerabilities of Europe's gas supply network, particularly its dependence on Russian and North African sources, and propose strategies to enhance resilience against supply disruptions. Grabau & Hegelich (2016) emphasise the divergent positions of EU member states toward Russian gas imports, exploring how these differences influence the EU's external gas policy. They stress the disagreements surrounding projects like Nord Stream, South Stream and Nabucco and discuss how these debates affect the EU's supply security. Newell & Carter (2024) develop a framework to understand supply-side climate policies, focusing on fossil fuels. The authors discuss how these policies, including production restrictions and market interventions, influence supply-side factors in the natural gas market and contribute to climate change mitigation efforts.

2. LITERATURE REVIEW

Gas markets are regionally fragmented, in contrast to globalised oil market (Siliverstovs et al., 2005; Wiggins & Etienne, 2017; Wang et al., 2020). Natural gas prices are set independently in different markets, especially after the shale

gas revolution in the USA (Geng et al., 2016; Wakamatsu & Aruga, 2013; Zhang & Ji, 2018). Gas prices in the USA are set in the Henri Hub gas hub, while European prices are a mix of gas prices from NBP and TTF hubs. Asian gas prices are still indexed to the Japanese oil price (JCC) where the indexation of oil exogenously sets the gas price and differentiates East Asian gas economies from other market-based economies (Shi & Variam, 2017). Wang et al. (2020) examine the impact of market reforms on natural gas import prices in China, and provide a valuable comparative perspective on how market reforms and unique regional characteristics shape natural gas prices in different parts of the world, reinforcing why direct comparisons between, for example, Asian and European gas markets may not be straightforward. This regional specificity means that pricing mechanisms and influencing factors can differ significantly across continents.

After the recent separation of USA gas and oil market, it is important to understand how European natural gas prices react to supply and demand shocks, to identify the effect of each shock on gas price volatility. Most authors, due to data availability, study the American market. Research shows that the correlation between gas and oil prices is weaker than in Europe and that a similar separation is happening in Europe as well, considering the recent shift to the GoG pricing model (Erdos, 2012). The European mechanism of price setting is still relatively unexplained, even though researchers tried to shed light on this issue in their national economies. Such examples are given for Germany by Nick & Thoenes (2014) or for the Netherlands by Hulshof, van der Maat & Mulder (2016) – but there is a lack of quality research on the European level. Nick & Thoenes (2014) use a structural VAR model to explain how gas prices in Germany are affected. Their findings indicate that short-run gas prices are significantly affected by factors such as air temperature, gas storage and supply disruptions. In the long run, however, they find that gas prices are primarily dependent on oil and coal prices. This study, while focusing on a national economy within Europe, provides a valuable benchmark for understanding the differing impacts of various drivers across time horizons and serves as a point of comparison for broader European-level research.

Hulshof, van der Maat & Mulder (2016) show that the TTF natural gas prices are only affected by oil price fluctuations in the short run, and that they react to factors specific to the European market (gas storage, air temperature and wind electricity generation). This study's findings contribute to a nuanced understanding of the factors that shape spot prices in Europe's leading gas hub, affirming the partial influence of oil in the short term while underscoring the role of regional market fundamentals.

Heather's two works are instrumental in understanding the evolution and significance of natural gas trading hubs in Europe. Heather (2012) highlights the growing importance of hubs such as the National Balancing Point (NBP) in the United Kingdom and the Title Transfer Facility (TTF) in the Netherlands, particularly in the face of Brexit uncertainties and declining UK domestic gas production. Building on this, Heather (2020) further emphasises the supremacy of TTF, which emerged as the main European and global reference for gas prices. By 2016, TTF surpassed NBP in trade volume and became the primary hedging and trade point for European gas. Its role has expanded to serve as a referent price point for global LNG trade, especially as Europe has increased its attractiveness to LNG exporters through infrastructure development and strategic decision to reduce reliance on Russian gas.

Our study focuses on a broader European market, which is to a great extent dependent on gas imports through pipelines, making it an interesting setting for researching the drivers of natural gas prices. We employ a vector autoregressive model with exogenous variable (VARX) to estimate the effects of different variables on gas prices. Six essential drivers of natural gas prices in the European market are identified. The interactions between supply and demand deviations from average air temperature values and gas storage levels, and coal and oil prices are analysed as variables affecting the price of natural gas. The model enables us to deal with the endogeneity of gas market variables, such as gas storage and supply from LNG. This is a key methodological contribution distinguishing our work from that of most other authors, such as Brown & Yücel (2008), Mu (2007), and Ramberg & Parsons (2012), who view gas storage as an exogenous variable and do not consider the growing role of LNG. The assumption of gas storage exogeneity shows that storage operators do not adjust their influx of gas to market conditions, which is a restrictive assumption for liberalised gas markets. Through this advanced methodology, our research provides novel empirical insights into the short and long-run determinants of European natural gas prices, notably confirming the significant role of coal prices and the limited impact of oil prices and temperature.

3. MATERIALS AND METHODS

Our dataset consists of 96 observations of monthly data from January 2016 to December 2023 in the EU. It is a sample that spreads over the period of the deregulated European market in which the TTF became the single most liquid gas hub. The model consists of natural gas prices in Europe, Brent crude oil prices, Northwest Europe coal prices, deviation from the average heating degree

threshold in the EU, deviation from the average filling levels of natural gas storage capacity in the EU and LNG imports in the EU27. Figure A.1 in the Appendix shows time series used in the analysis, while Table 1 summarises the variables used in our study.

Table 1. Description of Used Variables

No.	Variable name	Description	Unit	Data source
1	*stemperature*	Deviation of average and real HDD during the observed period	Degrees Celsius (°C)	Eurostat/Agri4Cast
2	*sbrentprice*	Brent crude oil European spot price	US Dollars per barrel	Energy Information Administration (EIA)
3	*scoalprice*	Northeast Europe coal price	US Dollars per tonne	McCloskey
4	*sLNG*	LNG imports in EU27 countries	Million cubic meters (mcm)	Eurostat Bruegel
5	*sstorage*	Deviation of real storage fullness from the monthly average	Percentage points (%)	Gas Infrastructure Europe (GIE)
6	*sgasprice*	TTF day-ahead natural gas price	British Thermal Unit	IMF

Source: Authors' compilation

The model includes six variables. Many factors of supply and demand determine natural gas prices and do not allow for a rudimentary model specification. Time series are first differenced to obtain stationarity. Then, they are seasonally adjusted by the moving average (MA) smoothing method that gives equal weights to all observations.

Natural gas prices. We use the day-ahead prices of TTF from the International Monetary Fund (IMF). The day-ahead price is set by the current supply and demand of subjects that operate in that market. Spot prices reflect valid signals, such as short-term shocks, a demand increase caused by temperature variations or an unexpected shortage, significantly affecting the spot market.

TTF is a good proxy, not only because it has become the main European gas hub, but it is also the global reference for gas prices (Heather, 2020). TTF surpassed NBP in 2016 and now represents the hub with the highest trade volume in Europe (IGU, 2017). It serves as a reference point for natural gas traded in Europe and most countries define their prices based on the prices of gas in this hub, especially those countries in northeastern Europe that are directly connected to the Netherlands' pipelines. In recent years, TTF has also become a referent price point for global LNG trade, as Europe once again became an attractive

destination for LNG exporters, due to its many gas-powered power plants, large storage capacity and the decision of the EU to stop using Russian gas.

Deviation from the average heating degree (temperature) threshold in the EU. We consider the demand for natural gas, especially for heating purposes, to be highly sensitive to air temperature changes. In a liberalised market, such as the one in Europe, storage operators are expected to account for predictable seasonal demand volatility caused by air temperature variations. Because of this, we only consider unexpected air temperature variations to be relevant. Therefore, we focus on deviations from the normal seasonal weather patterns. We use Heating degree days (HDD) as an indicator. It is based on weather conditions and designed to describe energy needs for heating purposes. It starts from the internationally defined threshold of 18°C[1]. Based on the data obtained from the Agri4Cast, we calculate the deviation of HDD from average values for the reference period, to estimate the effect of unexpected weather shocks on the prices of natural gas.

Brent crude oil price. We adjust our model in monthly frequency for seasonal weather patterns and data on gas storage. The choice of this frequency limits the use of gross domestic product (GDP) as a proxy for the business cycle. However, spot oil prices can also partially reflect the macroeconomic environment in the long run (Xia et al., 2017). Another channel through which oil affects the European natural gas price is the imports of LNG from Asia. In Asian contracts, oil affects the LNG price setting by about 15%, with a downward trend of 11-12% (Pande, 2024).

Coal prices. The model accounts for spot coal prices from three key European ports – Amsterdam, Rotterdam and Antwerpen, to capture the interaction of gas and coal for electricity generation. Apart from oil, coal is as significant for heating and electricity generation. By accounting for oil and coal prices, we include the effects of electricity generation in our model.

Natural gas storage. European natural gas storage enables efficient and secure operation of the entire continental natural gas system. Storages represent an additional source of gas supply on winter days and allow for flexibility, as the consumption during winter doubles compared to summer.

We use data on the level of gas storage fullness, as storage operators constitute a part of the supply (the withdrawal) and a part of the demand (injection). Gas

1 If Tim ≤ 15°C then [HDD = ∑i(18°C - Tim)], else [HDD = 0] where Tim is average temperature of day, e.g.: if the average daily air temperature is 12°C, value of HDD for that day is 6 (18°C-12°C). Only the days with the average air temperature of 15°C or below are taken into consideration for the calculation of HDD.

Infrastructure Europe (GIE) publishes data on storage fullness. We first construct an average seasonal pattern based on that data. We use the percentage of fullness instead of absolute values to account for the change in total storage capacity. Then we calculate the difference between the real percentage and the average monthly fullness of storage capacity. The difference between the real and average monthly fullness is an indicator of deviation from the monthly pattern.

LNG imports into the EU. Considering that the EU is a net importer of LNG, whose role rose to prominence in 2022 with the EU's attempt to decrease dependence on gas coming through pipelines, we include this indicator in the model as it reflects the current situation on the supply side of the European market.

3.1. Methodology

The European market saw significant changes in the past years that need to be included in the study of gas price drivers. One of the tools for the analysis of the dynamics of multiple time series is vector autoregression (VAR). VAR expresses a vector of observed variables as a function of its lags. In getting to VAR we start from univariate autoregression, where a stationary time-series variable y_t can often be modeled as depending on its own lagged values:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} \alpha_2 y_{t-2} + ... + \alpha_k y_{t-k} + \epsilon_t$$

When one analyses multiple time series, the natural extension to the autoregressive model is the vector autoregression, or VAR, in which a vector of variables is modeled as dependent on their lags and the lags of every other variable in the vector.

A two-variable VAR with one lag is expressed as following:

$$y_t = \alpha_0 + \alpha_1 \, y_{t-1} \alpha_2 x_{t-1} + \epsilon_{1t}$$
$$x_t = \beta_0 + \beta_1 y_{t-1} \beta_2 x_{t-1} + \epsilon_{2t}$$

The VAR model with endogenous variables may be written as:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_k Y_{t-k} + \epsilon_t \quad \text{.....(1)}$$
$$(\varepsilon_t \varepsilon_t') = \sum \quad \text{.....(2)}$$

Some authors employ Markov switching or break the observed period into subperiods. Domfeh (2023) uses Markov switching but primarily to investigate the natural gas-coal relationship and ascertain gas price regime changes as explained by coal price variability. Hou & Nguyen (2018) do the similar. Another way is to split the observed period into samples to estimate the model separately for different regimes (before and after the structural breaks). Nick & Thoenes (2014) use this approach, as their analysed period includes the Russian-Ukrainian Gas Conflict of 2009, the Arab Spring and the Civil War in Libya in 2011, and Supply Interruptions of Russian Natural Gas Deliveries in February 2012.

We introduce a dummy variable in a VAR for the COVID-19 pandemic period to isolate its impact. Introducing a dummy variable helps to handle structural breaks as observations include the pandemic period. Therefore, we use VAR model with exogenous variable (VARX).

The VARX method is an extension of the VAR model that allows exogenous variables. VARX, the specific case of the VAR methodology, allows imposing restrictions by setting some variables as exogenous and by imposing certain restrictions on the relationship among endogenous variables. The VARX approach is particularly important when external influences, market interventions or policy changes affect research questions and ensures the model remains robust.

Relation (1) with exogenous variable (VARX) may be written as:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_k Y_{t-k} + BX_t + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where Y_t is a 6×1 vector of endogenous variables at time t, A_i are 6×6 coefficient matrices for each endogenous variables lag i (where i=1,2,...,k), B is a 6×1 coefficient vectors for the exogenous variable, X_t is scalar exogenous variable at time t, ε_t is 6×1 vector of error terms (innovations) assumed to be white noise with zero mean and a covariance matrix Σ.

If all we care about is characterising the correlations in the data, then the VARX is all we need.

However, the VARX may be unsatisfactory for two reasons. First, (1) allows for arbitrary lags but does not allow for contemporaneous relationships among its variables. Researchers often link variables contemporaneously, and if we wish to use the VARX for it, it must be modified to allow for such contemporaneous relationships among the model variables.

This becomes a central issue in the impulse-response analysis, where it is important to know the contemporaneous effects of a shock. Usually, this is addressed using orthogonal impulse responses, where the correlation between the errors is obtained from the (lower) Cholesky decomposition of the error covariance matrix. Cholesky relies on a mathematical transformation that is sensitive to the ordering of variables and transforms residuals into uncorrelated shocks.

A VARX model that allows for contemporaneous relationships among endogenous variables may be written as:

$$A_0 Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_k Y_{t-k} + BX_t + \varepsilon_t \quad \text{.....(4)}$$

With a 6×6 covariance matrix of residuals:

$$\Sigma = E[\varepsilon_t \varepsilon_t^T] \quad \text{.....(5)}$$

Here we have a new notation (the A_0) that characterises the contemporaneous relationships among the endogenous variables in the VARX.

When writing down a VARX, one makes two basic model selection choices. First, one chooses which variables to include in the VARX (and which variable(s) to set exogenous). This decision is typically motivated by the research question and guided by theory. Second, one chooses the lag length using the formal lag-length selection criteria available. Once the lag length has been determined, one may proceed to estimation; once the parameters of the VARX have been estimated, one can perform post-estimation procedures to assess model fit. Using the Akaike Information Criterion (AIC) and Hannan–Quinn (HQIC), we define the VARX model with a length of seven lags. SBIC indicates a different lag length, but there is strong autocorrelation of the error term on it Σ.

The second deficiency of the VARX is that its error terms will, in general, be correlated. We wish to decompose these error terms into mutually orthogonal shocks. Why is orthogonality so important? When we perform impulse–response analysis, we ask the question, "What is the effect of a shock to one equation, holding all other shocks constant?" To analyse that impulse, we need to keep other shocks fixed. But if the error terms are correlated, then a shock to one equation is associated with shocks to other equations. To orthogonalise the residuals, we preform Cholesky decomposition on Σ:

$$\Sigma = PP^T \quad \text{.....(6)}$$

After applying Cholesky, the error term ε_t is replaced. The relationship between residuals (ε_t) and orthogonal shocks (u_t) may also be written as:

$$\varepsilon_t = Pu_t \quad \text{.....(7)}$$

Where:

- P: (6×6) lower triangular matrix obtained from the Cholesky decomposition of the covariance matrix Σ of ε_t ($\Sigma = PP^T$).
- u_t: (6×1) vector of orthogonal shocks with $u_t \sim N(0,I)$.

Rewrite relation (4) in a form where the contemporaneous relationships are disentangled. Premultiply the system by A_0^{-1} to isolate the endogenous variables. Also substitute $\varepsilon_t = Pu_t$:

$$Y_t = A_0^{-1}A_1Y_{t-1} + A_0^{-1}A_2Y_{t-2} + \ldots + A_0^{-1}A_kY_{t-k} + A_0^{-1}BX_t + A_0^{-1}Pu_t \quad \text{.....(8)}$$

Where:

- A_0^{-1} is the inverse of the contemporaneous relationship matrix.
- $A_0^{-1}P$ is a key matrix. It maps orthogonal shocks (u_t) into the system's innovations.

Moreover, we can write:

$$Y_t = C_1Y_{t-1} + C_2Y_{t-2} + \ldots + C_kY_{t-k} + DX_t + Pu_t \quad \text{.....(9)}$$

Where:

- $C_i = A_0^{-1}A_i$: Transformed coefficients for lagged endogenous variables.
- $D = A_0^{-1}B$: Transformed coefficients for the exogenous variable and its lags.
- Pu_t: The orthogonal shocks scaled by the P matrix.

In relation (9) shocks are orthogonal and interpretable, with a diagonal covariance matrix (I). The contemporaneous relationships are explicitly incorporated into P. The coefficients C_i and D are transformed by A_0^{-1}, reflecting how contemporaneous interactions influence lagged dynamics and exogenous effects.

4. RESULTS

By following these steps, we write down a model to obtain shocks and compute impulse-response functions (IRF). We use monthly observations on the Coal price, Brent price, LNG import, Gas storage and Temperature from 2016 to 2023 to trace the response of the endogenous variables to orthogonal shocks over time. We use VARX to model the factor's interrelationships in the European natural gas market. This approach analyses transmitting channels (mechanisms) that affect the variable of interest.

We generate IRF natural gas prices on variables impulses from a model, thus accentuating the dynamic effects of the natural gas market. Figure 1 presents the estimated IRFs for European natural gas prices.

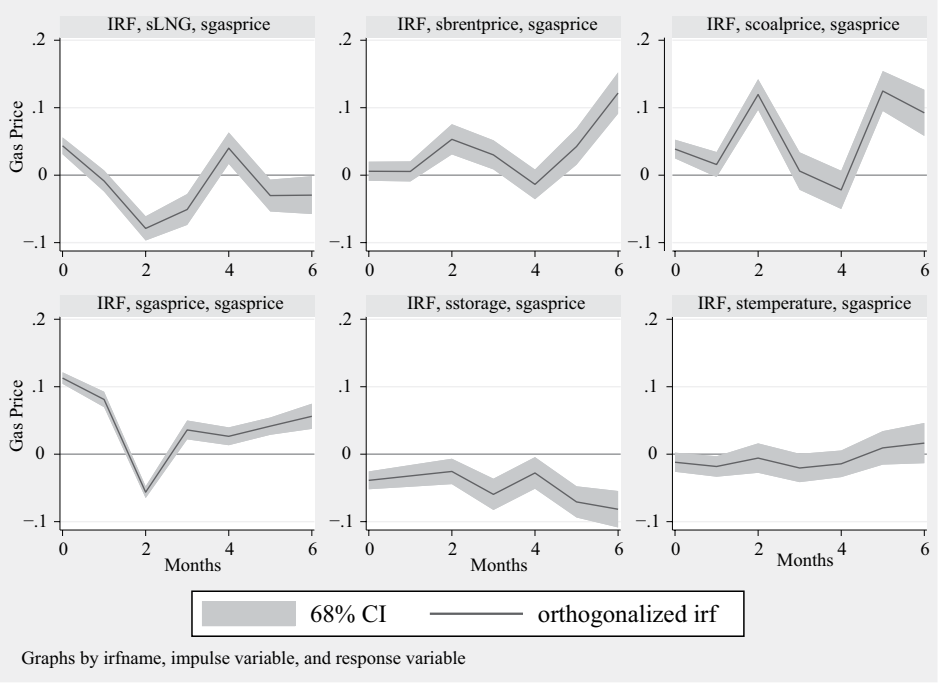

Figure 1. Responses of natural gas prices to shock from the other variable (response is to Cholesky one s.d. innovations 2 s.e.).
Source: Author's calculation

The impulsive response of natural gas prices is in line with the economic theory. There is a clear effect of shock caused by the LNG, which increases the supply and decreases the price of natural gas in the short run while stabilising it in the

long run to a level lower than the one before the shock. Obadi & Korcek (2020) reach the same finding, as additional LNG supply has a negative effect, lowering the price of natural gas traded on the European market.

Functions of the impulse-response of natural gas to oil and coal prices provide evidence of different connections between energy products and reveal their interconnections. Gas prices react positively to shocks in oil and coal prices but have a different pattern. Shocks in coal prices promptly affect gas prices, causing a cyclical movement of gas prices. Nick & Thoenes (2014) find that oil and coal price shocks result in more persistent effects. Gas prices are much more affected by changes in coal than in oil prices and reach their peak in the fifth month after the shock occurs. On the other hand, oil prices affect gas prices in the medium run and have a delayed and weaker relationship, which is in line with Hulshof, van der Maat & Mulder (2016). Oil price has a small positive impact on gas prices, partly due to remaining oil-indexation contracts, which allow traders to arbitrage between spot and contract gas, influencing hub prices.

The model clearly shows a segmentation of the gas market, including a shift from OPI to GoG, as European prices have a stronger reaction to coal prices in the long run.

The interdependence of gas, oil and coal is at the core of the European energy market. Gas and coal, as the primary source of energy in electricity production, are mutually competitive. This implies that there is a positive cross-elasticity i.e. that a rise in coal prices increases demand for gas, and consequentially, a rise in gas prices.

The cyclical character is most prominent with variables Temperature and Storage (Figure A.1). A higher level of storage fullness has a negative effect on gas prices, as it indicates that there is no excess demand on the spot market. On the other hand, when storage is empty, increased demand on the spot market creates an upward pressure on gas prices because of the storage injection process. Brown & Yücel (2008) and Nick & Thoenes (2014) find storage shocks lead to short-lasting effects on the gas prices. Cartea & Williams (2008) argue that deviations from the expected storage cycle are most relevant for sport price development.

We expected cold weather would lead to a short but significant increase in gas prices, but the analysis of the impulse response has a different result. The temperature has a cyclical character and, due to its natural seasonality, does not have an excessive influence on explaining natural gas movements which is contrary to the observed *a priori* assumption.

After identifying the dynamics of the European gas market, we study the effect of these variables on the gas prices. We calculated the forecast error variance decomposition (FEVD) to quantify the effect of variable shocks and explain the role of each variable in the changes in gas prices. FEVD is presented in Table 2 and shows that coal prices, gas storage and LNG imports contribute the most to gas price volatility.

Table 2. Forecast Error Variance Decomposition for the European Natural Gas Price

	(1)	(2)	(3)	(4)	(5)	(6)
step	fevd	fevd	fevd	fevd	fevd	fevd
0	0	0	0	0	0	0
1	.007972	.001901	.084155	.084427	.106477	.715068
2	.018155	.002471	.06693	.097279	.075466	.739699
3	.009519	.054186	.300787	.059923	.15379	.421795
4	.014906	.061111	.258829	.108541	.173655	.382957
5	.017094	.06029	.250576	.113756	.187564	.37072
6	.013346	.063489	.35232	.137322	.145927	.287596

(1) irfname = IRF, impulse = stemperature, and response = sgasprice
(2) irfname = IRF, impulse = sbrentprice, and response = sgasprice
(3) irfname = IRF, impulse = scoalprice, and response = sgasprice
(4) irfname = IRF, impulse = sstorage, and response = sgasprice
(5) irfname = IRF, impulse = SLNG, and response = sgasprice
(6) irfname = IRF, impulse = sgasprice, and response = sgasprice

Source: Author's calculation

Contrary to presumptions, temperature does not play a significant role in forming gas prices. Even though the demand for natural gas is seasonal and varies depending on the weather, our results obtained with the IRF and FEVD do not indicate that this brings a significant change in gas prices. According to Gas Infrastructure Europe, European storages can hold 4 months of gas demand (Gas Infrastructure Europe [GIE], 2025), which is quite a long period (EU27 gas storage capacity is cca 115 bcm ≈ 30% of annual gas consumption in the EU27). Therefore, a possible explanation is that a flexible natural gas supply absorbs sudden (weather-caused) increases in gas demand.

We relate it to the findings of Nick & Thoenes (2014) and Domfeh (2023). They capture immediate temperature impact through heating or cooling demand, which loses intensity quickly over time, indicating a short-term impact of these shocks. Nick & Thoenes (2014) find that only extraordinarily cold weather results in an immediate and strong increase in the natural gas price; the increase lasts only for two weeks, indicating that temperature deviation has rather short-term effects.

Even in the short run, gas prices can be better explained using the developments in the market for coal, as variations in coal prices have the single strongest effect on setting the price of gas, explaining about 35% of gas price variations six months after the shock. Long-run gas price variations are affected by coal prices, storage and LNG. Their cumulative effect makes for 64% of gas price variations and can forecast gas prices up to six months in advance.

In the short run (up to two months), LNG imports and gas storage have a crucial role in setting the price of natural gas. These explain about a fifth of gas price fluctuations. This is in line with the fact that gas storage balances short-run mismatch of supply and demand in the natural gas market. This effect becomes stronger with time and is accompanied by the coal price effect that also becomes stronger. On the other hand, results confirm that oil prices do not have an impact on European gas prices, which is aligned with the switch from OPI to GoG. The explanatory power of oil prices and air temperature is low for all time horizons.

5. DISCUSSIONS AND CONCLUSIONS

We researched six factors in explaining the changes in European natural gas from January 2016 to December 2023. Our key research question was whether the chosen factors drive the natural gas prices in Europe, with a focus on the interconnection between gas, oil and coal.

A scientific contribution lies in providing a comprehensive, Europe-level analysis of natural gas price drivers, addressing a recognised gap in the existing literature. Methodologically, we advance the understanding by employing a VARX model that explicitly accounts for the endogeneity of critical market variables like gas storage and LNG imports, a more realistic approach for liberalised markets compared to prior studies. Empirically, our findings strongly demonstrate the decoupling of natural gas and oil prices in Europe, confirming the dominance of the Gas-on-Gas pricing mechanism. We reveal that coal prices are the single most significant determinant of European natural gas prices in the long run, explaining approximately 35% of price variations, and that LNG imports and gas storage play a crucial role in short-run price setting. Conversely, we show that temperature and oil prices have a limited explanatory power over European gas prices.

Air temperature variations, as well as oil prices, have limited explanatory power. Oil does not play a role in determining gas prices in Europe as many gas importers have stopped using OPI in their long-term contracts due to fear of contracted prices rising significantly above market prices because of OPI. In this

context, the price elasticity of demand for gas from Russia, Algeria and Norway is a noteworthy field of future research.

The natural gas market in Europe experienced a profound transformation. Similar to the developments in the USA, European gas prices have diverged from oil prices and are completely shaped by market forces. This is confirmed by our findings.

Both the IRF and FEVD show that coal prices are the most relevant explanatory factors for gas prices in the observed period. Our results point out that we need to focus on the interdependence of gas and coal to better understand the dynamics of gas prices. Results of FEVD indicate that shocks in coal prices are the most important determinant of natural gas prices in this period which is marked by deregulation of the gas market. The rest of the variance in gas prices is attributed to other shocks specific to the European market, such as gas storage and LNG imports.

The next important finding is that there is a visible effect of LNG. We expect that with the development of the LNG infrastructure, European markets will become more integrated with other gas markets which will diminish the gap between regional gas prices. Prices in the European and US market are at the time still set independently. However, with further development of the critical infrastructure, intensified by Europe's efforts to become independent of Russian gas, these countries should definitely have a better position in negotiating gas prices. This will further bring the European natural gas price-setting mechanism closer to market conditions.

The results obtained cannot be generalised outside Europe due to the regional character of the markets. There are limitations to our study as the observed time frame is limited and there are potential explanatory variables that were not included in the analysis. Temperature shocks not substantially affecting gas prices could be due to flexible natural gas supply amortising gas demand changes without major price fluctuation. Capturing temperature effects is challenging as researchers must "catch" storage levels at the moment of temperature oscillations; when storage is low, a sudden drop in temperature drives higher natural gas demand (injection). When storage is high, the impact is minimal due to withdrawal.

It is not entirely surprising or unexpected that temperature shocks have a limited impact on natural gas prices, given the resilience and elasticity of supply along with storage mechanisms that smooth price fluctuation, but we expected at least some level of impact. Additionally, data and model limitations may not capture

the temperature effects accurately, as gas storage levels play a crucial role in this dynamic.

One of the directions of future research is constructing a more comprehensive model that would include financial indicators. Another one is developing a theoretical model that would explain the functioning of the European market in different geographical zones of the continent, as the market is not homogenous, and these zones have different patterns in natural gas consumption.

Bearing in mind the limitations, our findings contribute to a better understanding of the dynamics of the European gas market. Insights enhance the understanding of European gas market dynamics and highlight policy implications related to energy security and demand elasticity. An important implication of our study is that we proved that there was a divergence between natural gas and oil prices during the process of deregulation of the European gas market. Another noteworthy finding, based on the developments after the beginning of the war in Ukraine, is that the price elasticity of demand for natural gas in Europe is low due to its geographic position (proximity to Russia and Algeria enabled building pipelines from these countries, which Europe became reliant on). Low elasticity causes high natural gas prices (Figure A.1) during supply disruptions, often raising the question of whether gas prices should merely be defined by the market.

Conflict of interests

The authors declare there is no conflict of interest.

REFERENCES

Baltensperger, T., Füchslin, R. M., Krütli, P., & Lygeros, J. (2017). European Union gas market development. *Energy Economics, 66*, 466-479. https://doi.org/10.1016/j.eneco.2017.07.002

Brown, S. P. A., & Yücel, M. K. (2008). What Drives Natural Gas Prices? *The Energy Journal, 29*(2), 45-60. https://doi.org/10.5547/ISSN0195-6574-EJ-Vol29-No2-3

Cartea, Á., & Williams, T. (2008). UK gas markets: The market price of risk and applications to multiple interruptible supply contracts. *Energy Economics, 30*(3), 829-846. https://doi.org/10.1016/j.eneco.2007.03.001

Carvalho, R., Buzna, L., Bono, F., Masera, M., Arrowsmith, D., & Helbing, D. (2014). Resilience of natural gas networks during conflicts, crises and disruptions. *PLOS ONE, 9*(3), e90265. https://doi.org/10.1371/journal.pone.0090265

Domfeh, D. (2023). Perspective Chapter: DETERMINANTS OF NATURAL GAS PRICES IN THE UNITED STATES – A STRUCTURAL VAR APPROACH. *IntechOpen*. https://doi.org/10.5772/intechopen.1002182

Erdos, P. (2012). Have oil and gas prices got separated? *Energy Policy, 49*, 707-718. https://doi.org/10.1016/j.enpol.2012.07.022

Gas Infrastructure Europe (GIE). (2025). *Home*. https://www.gie.eu/

Geng, J. B., Q. Ji, & Y. Fan. (2016). The Impact of the North American Shale Gas Revolution on Regional Natural Gas Markets: Evidence from the Regime-Switching Model. *Energy Policy, 96*, 167-178. https://doi.org/10.1016/j.enpol.2016.05.047

Grabau, M., & Hegelich, S. (2016). The Gas Game: Simulating Decision-Making in the European Union's External Natural Gas Policy. *Swiss Political Science Review, 22*, 232-263. https://doi.org/10.1111/spsr.12202

Heather, P. (2012). *Continental European Gas Hubs: Are They Fit for Purpose?* United Kingdom: The Oxford Institute for Energy Studies. https://doi.org/10.26889/9781907555510

Heather, P. (2020). *European traded gas hubs: the supremacy of TTF*. Available at: https://www.oxfordenergy.org/publications/european-traded-gas-hubs-the-supremacy-of-ttf/

Hou, C., & Nguyen, B. H. (2018). Understanding the U.S. Natural Gas Market: A Markov Switching VAR Approach. *Energy Economics, 75*, 42-53. https://doi.org/10.1016/j.eneco.2018.08.004

Hulshof, D., van der Maat, J.-P., & Mulder, M. (2016). Market fundamentals, competition and natural gas prices. *Energy Policy, 94*, 480-491. https://doi.org/10.1016/j.enpol.2015.12.016

International Gas Union (IGU). (2017). *2017 Global Gas Report*. https://www.igu.org/resources/igu-world-lng-report-2017/

International Gas Union (IGU). (2021). *Wholesale Gas Price Survey*. https://www.igu.org/resources/global-wholesale-gas-price-survey-2021/

International Gas Union (IGU). (2023). *Global Gas Report 2023*. https://www.igu.org/resources/global-gas-report-2023-edition/

Lorefice, M. (2017). Gas price review arbitrations: Changing the indexation formula. *The guide to energy arbitrations* (2nd ed., pp. 207-216). Law Business Research.

Mu, X. (2007). Weather, storage, and natural gas price dynamics: Fundamentals and volatility. *Energy Economics, 29*(1), 46-63. https://doi.org/10.1016/j.eneco.2006.04.003

Newell, P., & Carter, A. (2024). Understanding supply-side climate policies: towards an interdisciplinary framework. *Int Environ Agreements 24*(1), 7-26. https://doi.org/10.1007/s10784-024-09631-3

Nick, S., & Thoenes, S. (2014). What drives natural gas prices? A structural VAR approach. *Energy Economics, 45*, 517-527. https://doi.org/10.1016/j.eneco.2014.08.010

Obadi, S. M., & Korcek, M. (2020). Driving Fundamentals of Natural Gas Price in Europe. *International Journal of Energy Economics and Policy, 10*(6), 318-324. https://doi.org/10.32479/ijeep.10192

Opolska, I., & Jakubczyk, M. (2013). The Drivers behind Gas Market Liberalization: Diversity of Gas Sources, Market Structure and Gas Prices. *International Business Research, 6*(7), 14-21. https://doi.org/10.5539/ibr.v6n7p14

Pande, S. (2024, May 7). Analysis: Asian LNG buyers seek to lower long-term contract slopes as markets shift. S&P Global. https://www.spglobal.com/

commodityinsights/en/market-insights/latest-news/lng/050724-analysis-asian-lng-buyers-seek-to-lower-long-term-contract-slopes-as-markets-shift

Ramberg, D. J., & Parsons, J. E. (2012). The Weak Tie between Natural Gas and Oil Prices. *The Energy Journal, 33*(2)*,* 13-35. https://doi.org/10.5547/01956574.33.2.2

Shi, X., & Variam, H. M. P. (2017). East Asia's gas-market failure and distinctive economics – A case study of low oil prices. *Applied Energy, 195*, 800-809. https://doi.org/10.1016/j.apenergy.2017.03.091

Siliverstovs, B., L'Hegaret, G., Neumann, A., & Von Hirschhausen, C. (2005). International market integration for natural gas? A cointegration analysis of prices in Europe, North America, and Japan. *Energy Economics, 27*(4), 603-615. https://doi.org/10.1016/j.eneco.2005.03.002

Wakamatsu, H., & Aruga, K. (2013). The Impact of the Shale Gas Revolution on the U.S. and Japanese Natural Gas Markets. *Energy Policy, 62*, 1002-1009. https://doi.org/10.1016/j.enpol.2013.07.122

Wang, T., Zhang, D., Ji, Q., & Shi, X. (2020). Market reforms and determinants of import natural gas prices in China. *Energy Policy, 196*(2), 117105. https://doi.org/10.1016/j.energy.2020.117105

Wiggins, S., & Etienne, X. L. (2017). Turbulent times: Uncovering the origins of US natural gas price fluctuations since deregulation. *Energy Economics, 64*(C)*,* 196-205. https://doi.org/10.1016/j.eneco.2017.03.015

Xia, X. H., Chen, B., Wu, X. D., Hu, Y., Liu, D. H., & Hu, C. Y. (2017). Coal use for the world economy: Provision and transfer network by multi-region input-output analysis. *Journal of Cleaner Production, 143,* 125-144. https://doi.org/10.1016/j.jclepro.2016.12.142

Zhang, D., & Ji, Q. (2018). Further Evidence on the Debate of Oil-Gas Price Decoupling: A Long Memory Approach. *Energy Policy, 113*, 68-75. https://doi.org/10.1016/j.enpol.2017.10.046

ПОКРЕТАЧИ ЦИЈЕНА ПРИРОДНОГ ГАСА У ЕВРОПСКОЈ УНИЈИ

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САЖЕТАК

Природни гас је кључни енергент и важан инпут у индустрији и производњи електричне енергије. Три директиве о гасу са почетка миленијума су либерализовале европско тржиште природног гаса. Директиве су подстакле прелазак са индексације цијене на нафту на механизам формирања цијене гаса на основу понуде и потражње на тржишту, што је дерегулисано тржиште учинило занимљивим предметом истраживања. У овом раду испитују се

покретачи цијена природног гаса на европском тржишту. За истраживање утицаја одабраних фактора користимо VAR модел са егзогеном варијаблом. Анализа импулсног одзива показује да је европско тржиште природног гаса краткорочно осјетљиво на увоз течног природног гаса и складиштење гаса, док је у дугом року уско везано за угаљ, остављајући по страни утицај нафте и температуре. Резултати декомпозиције варијансе прогнозе грешке откривају повезаност европских цијена природног гаса са кретањем цијена угља, складиштења гаса и увоза течног природног гаса збирно објашњавајући 64% варијација у цијенама гаса. Појединачно гледано, угаљ има највећу моћ објашњења с обзиром да одређује 35% варијабилности за период узорка.

Кључне ријечи: *цијена природног гаса, европске цијене гаса, природни гас, енергетска економија, тржиште природног гаса.*

APPENDIX

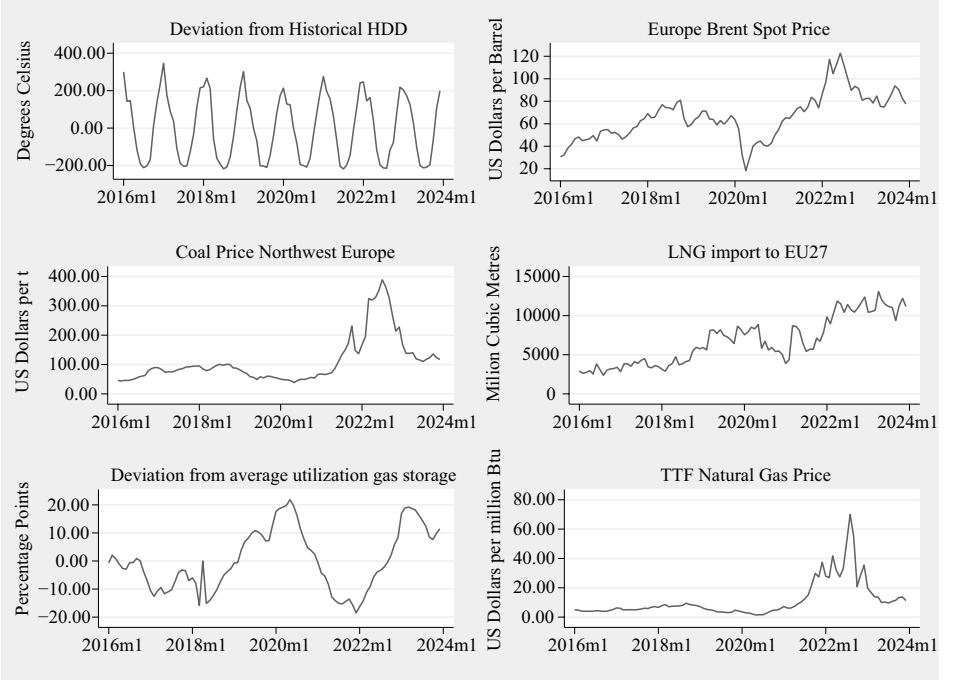

Figure A.1. Time Series of Used Variables
Source: Author's calculation

EXPLANING VARIABILITY IN THE GLOBAL LABOUR MARKET USING PRINCIPAL COMPONENT ANALYSIS AND MULTIPLE IMPUTATION

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ABSTRACT

This article investigates the underlying factors contributing to global labour market variability by applying Principal Component Analysis (PCA) and cluster analysis to data from 191 countries. Focusing on a broad set of economic, demographic and institutional indicators, the article seeks to uncover the primary dimensions shaping labour market dynamics worldwide. Key variables include GDP per capita, the Human Development Index (HDI), unemployment and poverty rates, labour freedom and corruption perception indices, average wages, and demographic characteristics such as population structure and migration rates. To ensure data completeness and robustness, multiple imputation was employed to address missing values. PCA was then used to reduce dimensionality and identify latent structures within the data. The resulting principal components were subsequently used in k-means clustering, which revealed four distinct clusters of countries sharing similar labour market profiles. The findings confirm that economic development and institutional quality are the dominant forces behind variations in labour market conditions across countries, while demographic variables, such as age distribution and migration, also play a meaningful role. These results support the hypothesis that clusters of countries with similar labour market profiles can be identified using the economic, demographic and institutional variables as inputs. The identification of country clusters further enables comparative insights and highlights region-specific challenges and opportunities. For policymakers, the study emphasises the importance of promoting economic stability, improving institutional frameworks and designing targeted interventions that consider demographic realities. It also calls for future research to incorporate additional socioeconomic dimensions and longitudinal data to more comprehensively capture the evolving nature of global labour markets.

1. INTRODUCTION

The functioning of the labour market is a complicated process and its mechanisms improve the economic soundness of the actors' economic decisions affecting the society's welfare (Lloret-Climent et al., 2020).

The labour market consists of three main actors: workers, companies and the state. Workers and companies have conflicting interests, as workers aim to maximise their earnings by working for higher wages, while companies seek to increase profits by hiring workers at lower wages (Borjas, 2020, p. 10). There are multiple approaches to studying the labour market, with no universal or comprehensive method. The opinions of various authors coincide in some areas but diverge in others (King, 1990, p. 10).

The goal of this article is to determine the principal components that explain the variability of a dataset containing variables which describe the labour market, such as workforce characteristics, economic, demographic, sociological and other variables, and to use the principal components as input in the cluster analysis. The variables were chosen based on the previous research on the factors that influence the labour market, and the hypotheses were formed accordingly.

The primary hypothesis is that the structure of global labour market variability can be described by a limited number of latent dimensions formed from economic, demographic and institutional variables. A secondary hypothesis is that these dimensions can be used to identify clusters of countries with distinct labour market profiles.

To test these hypotheses, the article employs Principal Component Analysis (PCA), a statistical method used to reduce the dimensionality of a dataset by transforming the original variables into a set of uncorrelated principal components that account for the maximum possible variance. (Greenacre et al., 2022). To enhance the analytical depth, cluster analysis, specifically k-means clustering, is performed on the PCA results to identify distinct groups of countries based on their labour market profiles (Umargono, Suseno, & Gunawan, 2020).

The next section reviews relevant literature on the determinants of labour market outcomes, laying the groundwork for the selection of variables and formulation of hypotheses. The methodology section describes the data sources, the treatment of missing data through multiple imputation, the procedures used to validate the assumptions for PCA, together with the k-means clustering methodology. The results section presents the extracted principal components, variance explained and findings from the cluster analysis. This is followed by a discussion of the substantive interpretation of the components and clusters, as well as their policy

implications. The final section summarises key insights and outlines directions for future research, including the integration of longitudinal data and additional socioeconomic indicators to capture evolving labour market dynamics more comprehensively.

2. LITERATURE REVIEW

Economic theory suggests that an individual will be active in the labour market and, thus form a labour supply, if the difference between their actual earned wage and the minimum acceptable wage is positive (Boeri & Van Ours, 2021, p. 4). In other words, wages and earnings are the primary variables in the *labour*-leisure model, determining the allocation of time between work and leisure (Borjas, 2020, p. 19).

Other researchers suggest that, among the macroeconomic factors, the level of income at the national level, the level of unemployment, social inequality and the share of the urban population have a significant influence on individuals' expectations about the benefits obtained through work (Zamfir et al., 2021). As relative earnings increase, labour supply also increases, beacuse workers compare their earnings with past earnings and the earnings of others (Bracha, Gneezy, & Loewenstein, 2015), or with reference points that reflect expected earnings or earnings which the individual aspires to (Kahneman & Tversky, 1979). Wage levels have been proven to play a significant role in boosting the innovative activities of workers (Pieroni & Pompei, 2008).

The significance of demographic characteristics is such that all changes in the labour market that cannot be explained by activity or employment rates can be attributed to changes in the population and its structure (Blanchard & Katz, 1992). Additionally, it is noted that differences in activity within a population group can be attributed to individual characteristics that are not directly measurable and cannot be included in the analysis (Ben-Porath, 1973).

The labour market is also shaped by the structure of the country's industry and the products it produces and exports, with countries that produce more sophisticated products generally having lower unemployment and higher employment rates (Adam et al., 2021).

3. METHODOLOGY

This study employs PCA to identify the major dimensions of variability in global labour market data. Before conducting PCA, we ensured that the data met key assumptions using Bartlett's Test of Sphericity and the Kaiser–Meyer–Olkin

(KMO) measure of sampling adequacy. In addition, a multiple imputation (MI) technique was used to handle missing data and provide robust estimates.

PCA is a factor-extraction technique that finds linear combinations of the observed variables which capture the maximum variance (Greenacre et al., 2022). To reduce the dimension of the dataset and to derive the new, uncorrelated variables, the original data are projected into a new coordinate system, where the first axis corresponds to the direction where the data varies the most; the second axis corresponds to the direction where the data varies the most after the first direction, etc. The first principal component is the projection of the original data to the first principal axis and captures the greatest amount of the variance in the data. The second principal component is the projection of the data on the second principal axis, explaining the greatest portion of variance remaining after the first principal component. Each subsequent principal component is uncorrelated with the other components and explains the greatest portion of variance, while being orthogonal to the preceding principal components (Kherif & Latypova, 2020).

The PCA analysis was conducted in the R programming language, using the *prcomp()* command. The command centres and standardises the data before performing singular value decomposition (SVD) to decompose the data matrix and compute the principal components and loadings (Harvey & Hanson, 2024). The data matrix X has samples in rows and values of respective variables in columns, so the SVD decomposition breaks the matrix X into three matrices:

$$X = UDV^T$$

where D is a diagonal matrix with all non-diagonal elements zero, and diagonal containing singular values, the columns of V give the principal axes that define the new coordinate system, and the scores, which are the projections of the data on principal axes, are obtained by XV or UD (Harvey & Hanson, 2024).

The requirements for the PCA were checked by running Bartlett's Test of Sphericity and calculating the KMO measure of sampling adequacy, using the command *check_factorstructure()* in the R programming language (R project, 2024). The Bartlett's Test of Sphericity checks whether the variables' correlation matrix is different from an identity matrix and calculates the probability that the correlation matrix has significant correlations among at least some variables using the test statistics:

$$\chi^2 = -\left(N - 1 - \frac{2p+5}{6}\right)\ln|R|$$

where R is a correlation matrix of p variables and N is the number of observations (Bartlett, 1951). This approach reduces the risk of obtaining random principal components and factors, and their incorrect interpretation (Tobias & Carlson, 1969).

The KMO measure of sampling adequacy, which ranges from 0 to 1, indicates the extent to which each variable in the dataset is predicted without error using the other variables (Kaiser, 1974). The measure is calculated as follows:

$$KMO = \frac{\sum_{j \neq k} r_{jk}^2}{\sum_{j \neq k} r_{jk}^2 + \sum_{j \neq k} p_{jk}^2}$$

where the is the correlation between the variables j and k, and is the partial correlation (R project, 2025). A higher KMO value indicates that patterns of correlations are relatively compact and thus that factor analysis (or PCA) should yield distinct and reliable factors. As a rule of thumb, KMO > 0.8 is considered **meritorious** (i.e., very good), 0.7–0.8 is **middling**, and below 0.6 indicates the need for remedial measures (Hair et al., 2018; Kaiser, 1974).

The dataset contained 10.58% of the missing data, with none of the variables exceeding 50%. If more than 50% of observations were missing for a particular variable, it was excluded from the analysis according to recommendations by Madley-Dowd et al. (2019). Since PCA cannot be conducted on the dataset containing missing data, multiple imputation (MI) was used to handle the missing data, as it was the most commonly recommended technique (Van Ginkel, 2023). Multiple imputation consists of three steps. The first step involves estimating the missing data multiple times (M) using a statistical model that describes the data structure, thereby resulting in M different versions of the dataset that differ only in the estimates of the missing data. The desired analysis is then applied to each of the M datasets, yielding an equal number of analysis results, which are then combined into a single consolidated result (Van Ginkel, 2023).

3.1. Data and Variables

For the PCA, data on a broad set of economic, demographic and institutional variables were collected for 191 countries. The variables were chosen based on the results of the previous analyses, in the sense that the author included variables that had previously been found to have an impact on the labour market. Over 50 different variables from more than 10 sources were considered, but only a 28 of them were retained due to the unavailability of a certain number of observations.

The data for the study was mostly collected from *The Global Economy* database, which compiles statistical data on over 300 indicators from several reliable sources,

such as national statistical institutes, the World Bank, the International Monetary Fund, the United Nations, the World Economic Forum and other sources (The Global Economy, 2024). Additionally, data on the Human Development Index (HDI) for 2021 was obtained from the United Nations Development Programme (UNDP) website, which publishes this index (UNDP, 2024). Data on average weekly working hours, average and minimum monthly wages, output per hour, average age and the percentage of young people not employed or in education was collected from the International Labor Organization (International Labor Organization, 2024). Data on migration rates was sourced from the Central Intelligence Agency (CIA, 2024).

Table 1 provides an overview of the variables included in the analysis, along with their descriptions and data sources.

Table 1: Overview of the Variables Included

Abbreviation	Description	Source
Country	Observed Country	*The Global Economy*
LPR	Labour Market Participation Rate	*The Global Economy*
GDPpcUSD	GDP per Capita, Current USD	*The Global Economy*
GDPpcPPP	GDP per Capita, Purchasing Power Parity	*The Global Economy*
HouseCons	Household Consumption as a Percentage of GDP	*The Global Economy*
UnempR	Unemployment Rate	*The Global Economy*
YUnempR	Youth Unemployment Rate, Ages 15-24	*The Global Economy*
FlabourF	Female Labour Participation Rate	*The Global Economy*
CorrIND	Corruption Perceptions Index (0-100)	*The Global Economy*
FreeCorrIND	Freedom from Corruption Index (0-100)	*The Global Economy*
BusIND	Business Freedom Index (0-100)	*The Global Economy*
LFreeIND	Labour Freedom Index (0-100)	*The Global Economy*
URB	Urban Population Percentage	*The Global Economy*
DEPEND	Dependency Ratio	*The Global Economy*
PerREFUG	Refugees as a Percentage of Total Population	*The Global Economy*
BrainDrainIND	Human Flight and Brain Drain Index (0-10)	*The Global Economy*
HappyIND	Happiness Index (0-10)	*The Global Economy*
DifMF_EMP	Male-Female Unemployment Rate Difference	*The Global Economy*
Popul	Population in Millions	*The Global Economy*
Per_F_Popul	Female Population Percentage	*The Global Economy*
HDI21	Human Development Index	*HDI*
PovertyR	In-Work Poverty Rate	*ILO*
MeanHRS	Average Weekly Working Hours	*ILO*
AvgWage	Average Monthly Wage	*ILO*
StatWage	Statutory Minimum Gross Monthly Wage	*ILO*
YNotEET	Percentage of Youth Not in Employment or Education	*ILO*
OutPerH	Output per Hour Worked	*ILO*
MeanAge	Average Population Age	*ILO*
Migr	Net Migration Rate	*CIA World Factbook*

Source: Developed by the author

Other variables that could have contributed to the analysis and provided additional insights were considered but ultimately not included due to a percentage of missing observations exceeding 50%. Excluded variables were the shadow economy as a percentage of GDP, health expenditure, the GINI index, percentage of impoverished population, percentage of GDP allocated to education, literacy rate, average years of education, percentage of highly educated population, percentage of religious population (by religion), cost of living index and level of social protection.

3.2. Sample Size

In the literature, various recommendations and opinions are given regarding sample size when conducting principal component analysis. However, formal guidelines for sample size in PCA and factor analysis are not extensive and often lack strong empirical support (Osborne & Costello, 2004).

Broadly, rules of thumb for sample size range from 3 to 6 observations per variable, with a minimum of 250 observations in total (Cattell, 1978, p. 508). Some authors state that the sample must have more observations than variables in the dataset and that 50 observations should be an absolute minimum for factor and principal component analysis, with a recommended ratio of 5 observations per variable (Hair et al., 2018, p. 101). Others suggest the sample size should be five times the number of variables (Gorsuch, 2014). Yet another common recommendation is a 10:1 ratio of observations to variables (Nunnally, 1978, p. 421), although this recommendation is not backed by publicly published research (Osborne & Costello, 2004).

The ratio of elements in the sample to the number of variables used in this study is 6.8:1, indicating that there are nearly seven observations per variable. This meets the oft-recommended ratio of 5:1 or higher, meaning the sample size is five times greater than the number of variables. The total number of elements in the sample is 191, which also aligns with the guideline that the minimum sample size should be at least 50. An important aspect of this analysis is that technically no sampling was performed - all internationally recognised countries were considered. The dataset could not be expanded further because it already encompasses all available data given the scope of this research. Therefore, within the current research scope and available data, it is not possible to obtain a larger sample or more observations.

3.3. Missing Data and Multiple Imputation

After confirming that the sample size meets the basic recommendations for PCA and assembling the dataset with 28 variables and 191 observations, the next step in the analysis was to address the missing observations. Due to the secondary nature of the data and its unavailability, it was not possible to collect values for all 28 variables in all 191 observed countries, resulting in gaps in the dataset.

In the entire dataset, there is a total of 10.58% missing values. Among the variables included in the analysis, the variable AvgWage had the highest percentage of missing data at 47%, followed by PovertyR at 37%, HouseCons with 35%, HappyIND at 30% and PerREFUG at 18%. All other variables have less than 10% missing values. For the variable StatWage, missing values were replaced with 0, assuming that the legal minimum wage is not defined in countries where data is unavailable.

According to the recommendations of Van Ginkel (2023), the data will be completed using multiple imputation with M=100 iterations. In this way, 100 different datasets with filled missing values were created. The method used for filling in missing values was predictive mean matching (PMM), which imputes values by using available data and weighting them with an appropriate metric (Van Buuren, 2012).

3.4. Adequacy for Principal Component Analysis

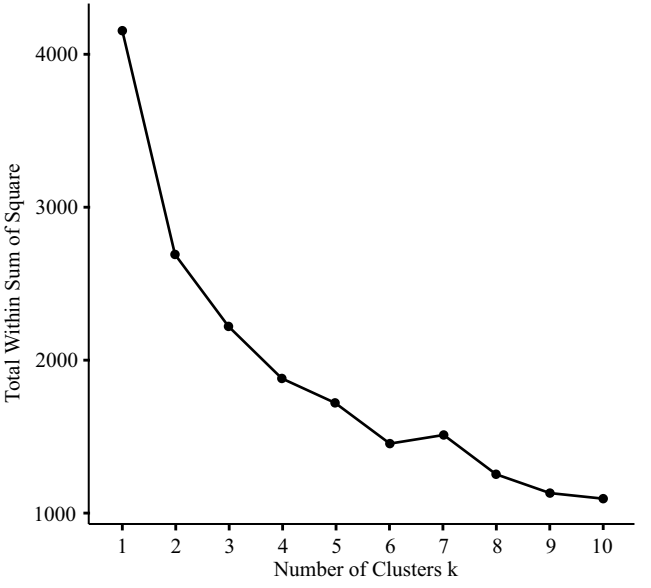
To verify the adequacy of the 100 imputed datasets for PCA, Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy were conducted on all 100 created datasets (R Project, 2024). In all 100 cases, Bartlett's test of sphericity had a p-value < 0.001, indicating a sufficient level of correlation among the variables to conduct PCA.

The overall KMO measure of sampling adequacy for the datasets ranged from 0.81 to 0.85, which places our data in the category of *good* in terms of suitability for factor analysis (Hair et al., 2018). Such KMO values confirm that the patterns of correlations are compact enough and that each variable has a significant amount of common variance to be explained by underlying factors. In other words, the imputed datasets are appropriate for PCA (Kaiser, 1974). Thus, both Bartlett's test and the KMO measure indicate that the data meet the key assumptions for PCA.

3.5. Cluster Analysis

Following the PCA, cluster analysis was applied to the principal component scores to identify groups of countries with similar labour market characteristics. The scores of the seven extracted principal components served as the input for clustering.

The clustering process used the k-means clustering technique. The optimal number of clusters was determined using the elbow method, which visually shows the differences in the sum of square error of each cluster. The most extreme difference forms the angle of the elbow showing the best cluster number (Umargono, Suseno, & Gunawan, 2020). This visual method indicated that four clusters were optimal for the dataset, as after *k=4* the rate of decrease slows down and the curve starts to flatten. The results are shown in Graph 1.



Graph 1: The Elbow Method
Source: Author's calculation

K-means clustering was then performed using the *kmeans ()* function in R, with the number of clusters set to four. This algorithm iteratively partitions the data into clusters by minimising the total intra-cluster variance (R Documentation, 2025). Each country was assigned to one of the four clusters based on the Euclidean distance to cluster centroids in the principal component space.

After assigning countries to clusters, average values of key labour market variables were calculated for each group. This allowed for an interpretation of the substantive characteristics of each cluster, including levels of economic development, institutional quality and demographic composition. The integration of PCA and clustering enables both dimensionality reduction and pattern recognition, providing a richer understanding of the global landscape of labour markets.

4. RESULTS

After collecting the data and checking their suitability for the PCA, the next step is to conduct the analysis. We created 100 imputed datasets using the multiple imputation method, which only differ in the values of the imputed observations. It is recommended to perform PCA on all of the imputed datasets separately and then pool the results into one outcome (Van Ginkel, 2023).

Following these recommendations, we carried out 100 separate PCAs (one for each imputed dataset), and then combined the results by averaging the PCA outcomes. In practice, this pooling was done by averaging the eigenvalues and component loadings across the 100 PCA runs.

Table 2 shows the eigenvalues of the correlation matrix for each principal component, based on the combined analysis.

Table 2: Eigenvalues

	Eigenvalues		Eigenvalues		Eigenvalues		Eigenvalues
PC1	10.911	PC8	0.894	PC15	0.358	PC22	0.099
PC2	3.328	PC9	0.730	PC16	0.288	PC23	0.082
PC3	2.267	PC10	0.630	PC17	0.255	PC24	0.050
PC4	1.948	PC11	0.582	PC18	0.222	PC25	0.042
PC5	1.273	PC12	0.522	PC19	0.169	PC26	0.038
PC6	1.105	PC13	0.472	PC20	0.149	PC27	0.019
PC7	1.035	PC14	0.397	PC21	0.118	PC28	0.015

Source: Author's calculation

According to Kaiser's criterion, principal components with eigenvalues greater than one (as seen in Table 2) should be included in the analysis since this criterion provides the number of interpretable components in empirical research (Kaiser, 1960). The number of retained principal components in this analysis should accordingly be seven.

Table 3 provides the standard deviations of each principal component and the proportion of total variance explained, both for each component individually and cumulatively. The standard deviation (SD) of a component is the square root of its eigenvalue. The proportion of variance is the eigenvalue divided by the total number of variables (28), and the cumulative percentage shows how much of the total variance is explained by all components up to the last one.

Table 3: Explained Variance

	Standard Deviation	Proportion of Variance	Cumulative Percentage
PC1	3.303	0.390	0.390
PC2	1.824	0.119	0.509
PC3	1.506	0.081	0.590
PC4	1.396	0.070	0.659
PC5	1.128	0.045	0.705
PC6	1.051	0.039	0.744
PC7	1.017	0.037	0.781
PC8	0.946	0.032	0.813
PC9	0.854	0.026	0.839
PC10	0.794	0.023	0.862
PC11	0.763	0.021	0.882
PC12	0.722	0.019	0.901
PC13	0.687	0.017	0.918
PC14	0.630	0.014	0.932
PC15	0.598	0.013	0.945
PC16	0.537	0.010	0.955
PC17	0.505	0.009	0.964
PC18	0.471	0.008	0.972
PC19	0.411	0.006	0.978
PC20	0.386	0.005	0.984
PC21	0.343	0.004	0.988
PC22	0.314	0.004	0.991
PC23	0.286	0.003	0.994
PC24	0.225	0.002	0.996
PC25	0.204	0.001	0.997
PC26	0.194	0.001	0.999
PC27	0.136	0.001	0.999
PC28	0.122	0.001	1.000

Source: Author's calculation

Based on Table 3, the first principal component alone explains about 39.0% of the variability in the dataset, and the second component explains about 11.9%, therefore together the first two components account for roughly 50.9% of the variance. Each of the remaining individual components explains less than 10% of the variance. All 28 principal components collectively explain 100% of the

variability, but in practice, one would focus on the subset of components with larger eigenvalues. In our case, the first seven components have eigenvalues above 1.0 (per Kaiser's criterion), and together they explain about 77.9% of the total variability. Therefore, we retain these seven principal components for further analysis.

Table 4 shows the structure of the retained principal components, namely the loadings of the original variables within each component on each of the first seven principal components. A higher absolute loading indicates that the variable is more strongly associated with that component.

Table 4: Retained Principal Components

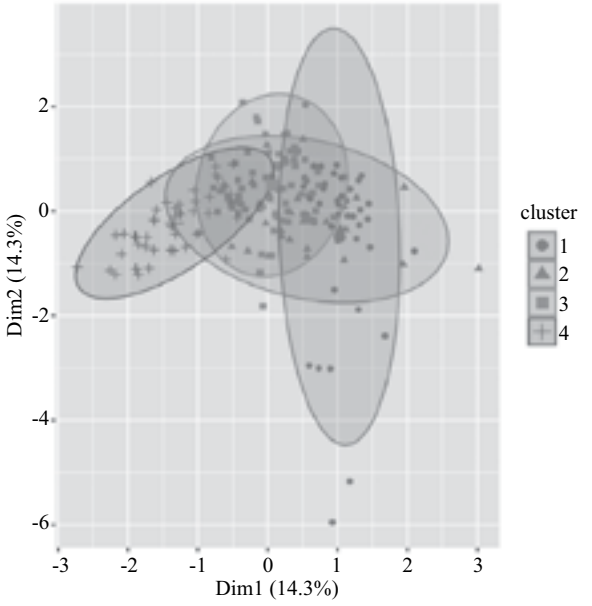
	PC1	PC2	PC3	PC4	PC5	PC6	PC7
GDPpcUSD	0.265	-0.001	-0.003	0.011	-0.023	-0.012	0.003
GDPpcPPP	0.277	0.000	0.011	0.010	-0.014	-0.006	0.006
HouseCons	-0.195	-0.027	-0.030	-0.003	0.015	-0.013	0.028
UnempR	-0.088	-0.006	-0.015	-0.012	-0.026	0.049	0.001
YUnempR	-0.050	-0.003	-0.011	-0.010	-0.033	0.076	0.000
LPR	0.065	0.005	0.008	0.004	-0.050	-0.010	0.004
FLabourF	0.066	-0.001	-0.055	-0.009	0.020	0.012	-0.007
CorrIND	0.257	0.003	-0.014	-0.005	-0.026	-0.009	0.003
FreeCorrIND	0.262	0.004	-0.017	-0.007	-0.026	-0.016	0.003
BusIND	0.256	-0.013	-0.012	-0.011	-0.008	-0.020	-0.008
LFreeIND	0.138	-0.020	-0.032	-0.023	-0.109	-0.088	-0.017
URB	0.203	0.003	0.019	0.016	0.038	0.015	0.010
DEPEND	-0.172	-0.008	-0.043	0.004	-0.006	-0.069	-0.014
PerREFUG	-0.024	-0.002	-0.008	-0.005	0.066	-0.208	0.013
BrainDrainIND	-0.256	-0.003	-0.013	-0.024	-0.003	-0.035	0.021
HappyIND	0.242	-0.001	-0.024	0.005	0.009	0.056	0.017
DifMF_EMP	0.086	0.003	-0.018	-0.023	0.015	0.035	0.007
Popul	-0.006	0.000	0.026	-0.005	-0.016	0.033	-0.087
Per_F_Popul	-0.032	-0.008	-0.058	-0.023	0.076	-0.015	-0.017
HDI21	0.277	-0.002	0.009	-0.005	0.023	-0.005	0.005
PovertyR	-0.092	-0.017	-0.047	0.028	-0.032	0.008	-0.011
MeanHRS	-0.079	0.007	0.064	-0.009	0.018	-0.076	0.012
AvgWage	0.232	-0.004	-0.031	0.012	0.000	-0.006	0.008
StatWage	0.195	-0.008	-0.011	-0.010	-0.005	-0.028	-0.006
YNotEET	-0.224	-0.007	-0.002	-0.014	-0.054	0.017	0.012
OutPerH	0.269	-0.004	-0.005	0.007	-0.005	-0.005	0.002
MeanAge	0.244	0.002	-0.001	-0.012	0.040	0.006	-0.004
Migr	0.066	-0.019	-0.013	0.045	-0.008	-0.040	-0.044

Source: Author's calculation

The loadings in Table 4 are used to interpret each principal component in substantive terms. High positive or negative loadings indicate which variables are most strongly associated with a component.

To identify country groupings with similar labour market profiles, k-means clustering was applied using the scores from the seven retained principal components.

The optimal number of clusters was determined using the elbow method, which showed a clear inflexion point at four clusters. The k-means algorithm was run with *k=4*, resulting in four distinct clusters of countries. The four clusters are given in Graph 2.



Graph 2: Cluster Plot
Source: Author's calculation

To visually represent the cluster structure, a two-dimensional projection of the high-dimensional PCA scores was employed using multidimensional scaling (MDS) of the Euclidean distance matrix (Hout, Papesh, & Goldinger, 2013). The resulting cluster plot displays the observations (countries) in a reduced space defined by Dim1 and Dim2, which together capture approximately 28.6% of the total variation in inter-country distances within the PCA space. Notably, Dim1 and Dim2 each account for 14.3%, indicating a balanced distribution of the variation preserved in the two-dimensional view.

The visual separation of clusters supports the findings from the PCA. Cluster 1 (red) is well-separated along Dim1, reflecting countries with high levels of economic development, institutional quality and productivity. Cluster 2 (green) and Cluster 3 (blue) exhibit partial overlap in the centre of the plot, consistent with their intermediate socio-economic profiles and transitional labour market structures. Cluster 4 (purple) is positioned distinctly on the left side, capturing low-income countries characterised by lower development indices, higher demographic dependency and labour market exclusion.

While the clusters are not entirely non-overlapping, their spatial arrangement in this plot illustrates the relative similarity and dissimilarity of countries based on their labour market features as represented by the PCA dimensions. The compactness of Cluster 1 and Cluster 4 suggests greater internal homogeneity, whereas the dispersion of Clusters 2 and 3 indicates more heterogeneity in transitional economies.

Additionally, Table 5 presents the average values of selected indicators by cluster, offering insight into the defining characteristics of each group.

Table 5: Cluster Means by Variable

Cluster	1	2	3	4
GDPpcUSD	54615	3856	11893	2443
GDPpcPPP	57416	7822	20357	3992
HouseCons	46.70	71.46	62.09	72.34
UnempR	4.90	16.95	7.12	4.54
YUnempR	13.16	34.42	17.74	8.25
LPR	63.68	47.62	60.61	64.77
FLabourF	42.36	32.65	43.76	44.35
CorrIND	67.76	31.84	44.18	29.75
FreeCorrIND	74.93	32.74	45.69	26.31
BusIND	78.88	47.90	65.04	44.50
LFreeIND	61.85	53.06	56.79	49.40
URB	83.89	59.06	61.94	41.04
DEPEND	49.98	63.61	49.91	75.48
PerREFUG	0.009	0.037	0.006	0.004
BrainDrainIND	2.31	6.53	5.25	6.62
HappyIND	6.67	4.58	5.66	4.43
DifMF_EMP	-1.20	-8.02	-0.98	-0.50
Popul	27.36	24.08	63.03	33.34
Per_F_Popul	48.25	50.20	50.81	50.14
HDI21	0.91	0.64	0.77	0.55
PovertyR	1.26	13.15	3.60	27.48

Cluster	1	2	3	4
MeanHRS	35.84	40.11	39.20	38.84
AvgWage	3573.59	1087.82	964.77	604.54
StatWage	1050.39	105.88	282.31	67.87
YNotEET	10.13	31.84	17.98	25.38
OutPerH	62761	13809.93	22344.46	5027.08
MeanAge	40.47	26.24	35.80	21.38
Migr	2.81	0.82	-1.71	-0.89

Source: Author's calculation

The cluster analysis reveals that economic development, demographic dynamics and institutional frameworks jointly shape national labour outcomes. Importantly, the clusters offer actionable groupings for comparative analysis, enabling countries to benchmark their performance and learn from peers facing similar structural conditions.

5. DISCUSSIONS

The PCA revealed that economic development, institutional quality and demographic composition are the most significant factors contributing to global labour market variability. The first principal component (PC1), which explains 39% of the total variance, captured a composite of variables including GDP per capita, the HDI, output per hour and institutional indicators such as business freedom and the perception of corruption. Countries scoring highly on this component tend to enjoy higher living standards, robust institutional frameworks and more efficient labour markets. This aligns with established economic theory, which posits that developed economies with effective governance structures tend to offer greater labour market stability and inclusion.

To translate these abstract dimensions into actionable insights, a k-means cluster analysis was applied to the scores from the first two principal components, together accounting for over 50% of the total variance. This step enabled the grouping of countries into four empirically grounded clusters that reflect distinct labour market regimes. The elbow method was used to determine the optimal number of clusters, identifying a clear inflexion point at four.

Cluster 1 is composed of high-income economies with advanced institutional infrastructure. These countries report the highest GDP per capita and HDI scores, coupled with low unemployment rates, high average wages and strong governance indicators. Labour force participation is high, particularly among

women, and labour productivity (measured by output per hour) is among the highest globally. Countries in this cluster also have relatively older populations, highlighting demographic ageing as a policy priority.

Cluster 2 represents lower-middle-income countries grappling with deep-seated labour market challenges. These include very high rates of youth unemployment, low female participation, weak business environments and moderate-to-low levels of HDI. Despite a younger demographic profile, the institutional barriers in these countries hinder effective labour market integration. Poverty levels remain elevated, and informal employment is likely pervasive.

Cluster 3 encompasses a mix of emerging economies with transitional characteristics. These countries show moderate levels of economic development and governance, and they occupy a middle ground in terms of unemployment, labour participation and wage levels. Urbanisation is more advanced than in Cluster 2, and female participation and governance scores are generally higher. However, the variability within this cluster suggests heterogeneous policy needs.

Cluster 4 includes the world's lowest-income countries, marked by systemic disadvantage. These nations score the lowest across nearly all indicators: GDP per capita, HDI, institutional quality and productivity. Although unemployment rates appear low, this likely reflects high levels of informal labour. The population in these countries is among the youngest globally, and working poverty is particularly acute. Educational and healthcare infrastructure may also be underdeveloped, compounding labour market exclusion.

The cluster plot in Graph 2 provides visual confirmation of these groupings. Cluster 1 is differentiated along the axis associated with economic and institutional development. Cluster 4 appears at the opposite end, encapsulating structural disadvantage. Clusters 2 and 3 show partial overlap, reinforcing their transitional nature but also hinting at internal diversity in development trajectories.

These empirically derived clusters offer a practical typology for comparative labour market analysis. For policy design, this typology supports a more tailored approach: countries in Cluster 1 might prioritise innovation, labour market flexibility and managing demographic ageing, Cluster 2 would benefit from targeted strategies to enhance youth employment and reduce gender disparities, Cluster 3 may focus on strengthening governance and skills development to sustain economic momentum, and Cluster 4 requires foundational investment in education, healthcare and institution-building to address widespread informality and exclusion.

Moreover, the clustering results highlight how macroeconomic and institutional indicators interact with demographic factors to shape labour market outcomes. For instance, countries with similar GDP per capita may still diverge significantly in labour inclusion due to governance quality or demographic structure. This reinforces the importance of integrated policy approaches that go beyond economic growth to address structural and institutional barriers.

In sum, the PCA-cluster integration offers a robust framework for understanding the structural diversity of global labour markets. It not only confirms the centrality of economic and institutional development but also elucidates how these factors combine with demographic and social variables to produce distinct labour market regimes. The findings offer a valuable lens for international benchmarking and policy planning.

Future research could expand this framework by incorporating time-series data to capture the evolution of labour market structures over time. Additionally, disaggregated regional analyses could explore intra-cluster variation, enhancing the precision and applicability of the typology. Exploring the impacts of digitalisation, climate change or migration shocks on cluster dynamics could also yield important insights into future labour market resilience.

6. CONCLUSIONS

This article identifies the key latent dimensions that explain variability in labour market conditions on a global level. Through the application of PCA on a comprehensive dataset of 191 countries, seven principal components that explain 77.9% of the total variability in the dataset on the labour market were identified.

In support of our main hypothesis, these principal components align with macroeconomic, demographic and institutional factors. Moreover, the auxiliary hypothesis - that living standards, as measured by indicators such as GDP per capita and the Human Development Index, are primary drivers - was substantiated by the strong loadings of these variables on the first principal component. This component alone accounted for 39% of the variance, reflecting a powerful structural axis that differentiates countries according to their economic development and institutional quality.

The cluster analysis further strengthened these hypotheses by demonstrating that the principal components not only reduce dimensionality but also provide a meaningful basis for classifying countries into distinct labour market categories. The four clusters were differentiated through k-means clustering, offering compelling empirical support for the theoretical propositions. Specifically, the

existence of well-defined clusters confirmed that countries do, in fact, group together in ways consistent with the structural dimensions captured by the PCA: primarily development level, institutional strength and demographic composition. Thus, the cluster findings validate and reinforce the hypothesis that structural macroeconomic and institutional differences underpin global labour market variability, with living standards emerging as the most decisive axis of differentiation.

Beyond dimensionality reduction, the article's major theoretical and empirical contribution lies in the integration of PCA with cluster analysis. Using the scores from the extracted principal components, a k-means clustering algorithm was used to reveal four distinct clusters of countries, each representing a unique labour market profile. This classification system adds interpretative depth to the PCA findings by translating abstract statistical patterns into tangible country groupings. Cluster 1 grouped high-income, institutionally robust countries with productive and inclusive labour markets. Cluster 2 represented lower-middle-income economies struggling with youth unemployment, gender inequality in labour participation and institutional fragility. Cluster 3 included transitional emerging markets with diverse demographic and institutional features. Cluster 4 contained the lowest-income countries with weak governance, high working poverty and young populations, where informality likely dominates labour market activity.

These clusters offer a powerful typology for understanding and comparing labour markets across diverse socio-economic contexts. The cluster plot differentiated these groups along the principal component axes, reinforcing the interpretive strength of the PCA and underscoring the robustness of the clustering procedure. Importantly, the clarity of the cluster separation lends further credibility to the PCA results by showing that countries naturally aggregate along key structural dimensions. The internal coherence of each cluster and the external distinctiveness between them provide strong support for the usefulness of this typology in comparative labour market research and policy analysis.

The used framework of combining PCA, multiple imputation to address missing data, and k-means clustering demonstrates the utility of statistical integration in capturing the complexity of labour market structures. The use of imputation ensured the integrity and completeness of the dataset, enabling a full exploitation of available information. PCA reduced multidimensional complexity while retaining explanatory power, and cluster analysis translated these results into an actionable classification. This integrative approach enhances the generalisability

and analytical utility of the findings, offering a replicable model for future cross-country labour market studies.

Future research could expand on the cluster analysis by examining its temporal stability. Applying this PCA-cluster framework to panel data would allow researchers to track how countries move between clusters over time and identify the forces driving those transitions. Such longitudinal analysis would help distinguish structural features from those that are policy-responsive or temporally volatile. Additionally, more granular regional or sub-national clustering could reveal patterns obscured at the global level, while the inclusion of additional variables, such as digital infrastructure, labour laws, education quality or political stability, could enrich the analysis. Finally, exploring how global trends like digitalisation, automation and climate migration intersect with the identified clusters would help ensure that this typology remains relevant in an evolving global labour landscape.

In conclusion, this study advances theoretical understanding and methodological precision in the analysis of global labour market variability. The identification of interpretable structural dimensions and their mapping into cohesive country clusters represents a significant step toward a unified framework for labour market comparison. These clusters are not only analytically robust but also practically valuable, providing policymakers with a framework for benchmarking and designing context-sensitive labour market reforms.

Conflict of interests

The author declares there is no conflict of interest.

REFERENCES

Adam, A., Garas, A., Katsaiti, M. S., & Lapatinas, A. (2021). Economic complexity and jobs: An empirical analysis. *Economics of Innovation and New Technology, 31*(1), 25–52. https://doi.org/10.1080/10438599.2020.1859751

Bartlett, M. S. (1951). The effect of standardization on a $\chi 2$ approximation in factor analysis. *Biometrika, 38*(3/4), 337-344. https://doi.org/10.2307/2332580

Ben-Porath, Y. (1973). Labor-force participation rates and the supply of labor. *Journal of Political Economy, 81*(3), 697-704. https://doi.org/10.1086/260065

Blanchard, O., & Katz, L. (1992). Regional evolutions. *Brookings Papers on Economic Activity, 23*(1), 1-76.

Boeri, T., & Van Ours, J. (2021). *The economics of imperfect labor markets* (3rd ed.). Princeton University Press.

Borjas, G. (2020). *Labor economics* (8th ed.). McGraw-Hill Education, New York.

Bracha, A., Gneezy, U., & Loewenstein, G. (2015). Relative pay and labor supply. *Journal of Labor Economics, 33*(2), 297-315. https://doi.org/10.1086/678494

Cattell, R. (1978). *The scientific use of factor analysis in behavioral and life sciences*. Plenum Press, New York.

CIA. (2024). *The World Factbook*. https://www.cia.gov/the-world-factbook/

Gorsuch, R. (2014). *Factor analysis* (2nd ed.). Routledge, London.

Greenacre, M., Groenen, P., Hastie, T., D'Enza, A. I., Markos, A., & Tuzhilina, E. (2022). Principal component analysis. *Nature Reviews Methods Primers, 2*(100), 1-10. https://doi.org/10.1038/s43586-022-00184-w

Hair, J., Black, W., Babin, B., & Anderson, R. (2018). *Multivariate data analysis* (8th ed.). Cengage Learning EMEA, Boston.

Harvey, D. T., & Hanson, B. A. (2024). *A comparison of functions for PCA*. https://cran.r-project.org/web/packages/LearnPCA/vignettes/Vig_07_Functions_PCA.pdf

Harvey, D. T., & Hanson, B. A. (2024). *The math behind PCA*. https://cran.r-project.org/web/packages/LearnPCA/vignettes/Vig_06_Math_Behind_PCA.pdf

Hout, M. C., Papesh, M. H., & Goldinger, S. D. (2013). Multidimensional scaling. *Wiley Interdisciplinary Reviews: Cognitive Science, 4*(1), 93–103. https://doi.org/10.1002/wcs.1203

International Labor Organization. (2024). *ILOSTAT.* https://ilostat.ilo.org/data/

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica, 47*(2), 263-292. https://doi.org/10.2307/1914185

Kaiser, H. F. (1960). The application of electronic computers to factor analysis. *Educational and Psychological Measurement, 20*(10), 141-151. https://doi.org/10.1177/001316446002000116

Kaiser, H. F. (1974). An index of factorial simplicity. *Psychometrika, 39*, 31–36. https://doi.org/10.1007/BF02291575

Kherif, F., & Latypova, A. (2020). Principal component analysis. In A. Mechelli & S. Vieira (Eds.), *Machine Learning* (pp. 209–225). Academic Press. https://doi.org/10.1016/B978-0-12-815739-8.00012-2

King, J. E. (1990). *Labour economics* (2nd ed.). Red Globe Press, London.

Lloret-Climent, M., Nescolarde-Selva, J.-A., Mora-Mora, H., Alonso-Stenberg, K., & Mollá-Sirvent, R. (2020). Modeling complex social systems: A new network point of view in labour markets. *IEEE Access, 8*, 92110-92119.

Madley-Dowd, P., Hughes, R., Tilling, K., & Heron, J. (2019). The proportion of missing data should not be used to guide decisions on multiple imputation. *Journal of Clinical Epidemiology, 110*, 63-73. https://doi.org/10.1016/j.jclinepi.2019.02.016

Nunnally, J. (1978). *Psychometric theory* (2nd ed.). McGraw-Hill, new York.

Osborne, J. W., & Costello, A. B. (2004). Sample size and subject to item ratio in principal components analysis. *Practical Assessment, Research, and Evaluation, 9*, 1-9. https://doi.org/10.7275/ktzq-jq66

Pieroni, L., & Pompei, F. (2008). Labour market flexibility and innovation: Geographical and technological determinants. *International Journal of Manpower, 29*(3), 216-238. https://doi.org/10.1108/01437720810878897

R Project. (2025). *Kmeans: K-Means Clustering*. https://www.rdocumentation.org/packages/stats/versions/3.6.2/topics/kmeans

R Project. (2024). *Check suitability of data for Factor Analysis (FA) with Bartlett's Test of Sphericity and KMO*. https://search.r-project.org/CRAN/refmans/performance/html/check_factorstructure.html

R Project. (2025). *Find the Kaiser, Meyer, Olkin Measure of Sampling Adequacy*. https://search.r-project.org/CRAN/refmans/psych/html/KMO.html

The Global Economy. (2024). *About the site*. https://www.theglobaleconomy.com/

Tobias, S., & Carlson, J. E. (1969). Brief report: Bartlett's test of sphericity and chance findings in factor analysis. *Multivariate Behavioral Research, 4*(3), 375–377. https://doi.org/10.1207/s15327906mbr0403_8

Umargono, E., Suseno, J. E., & Gunawan, S. K. V. (2020). K-means clustering optimization using the elbow method and early centroid determination based on mean and median formula. In *Proceedings of the 2nd International Seminar on Science and Technology (ISSTEC 2019)* (pp. 121–129). Atlantis Press. https://doi.org/10.2991/assehr.k.201010.019

UNDP. (2024, February 2). *Human development index (HDI)*. https://hdr.undp.org/data-center/human-development-index#/indicies/HDI

Van Buuren, S. (2012). *Flexible imputation of missing data*. Chapman & Hall/CRC Press, New York.

Van Ginkel, J. (2023). Handling missing data in principal component analysis using multiple imputation. In L. Van der Ark, W. Emons, & R. Meijer (Eds.), *Essays on contemporary psychometrics* (pp. 141-161). New York, NY: Springer. https://doi.org/10.1007/978-3-031-10370-4_8

Zamfir, A. M., Năstasă, A., Aldea, A., & Molea, R. (2021). Factors shaping labour market participation. *Postmodern Openings, 12*(1), 91-101. https://doi.org/10.18662/po/12.1/247

ОБЈАШЊЕЊЕ ВАРИЈАБИЛИТЕТА НА ГЛОБАЛНОМ ТРЖИШТУ РАДА КОРИШЋЕЊЕМ АНАЛИЗЕ ГЛАВНИХ КОМПОНЕНТИ И ВИШЕСТРУКЕ ИМПУТАЦИЈЕ

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САЖЕТАК

Овај чланак истражује основне факторе који доприносе варијабилности глобалног тржишта рада, примјеном анализе главних компоненти (PCA) и кластер анализе на подацима из 191 земље. Користећи широк скуп економских, демографских и институционалних показатеља, анализа има за циљ да открије примарне димензије које обликују динамику тржишта рада

широм свијета. Кључни показатељи обухватају БДП по глави становника, индекс хуманог развоја (HDI), стопе незапослености и сиромаштва, индексе слободе рада и перцепције корупције, просјечне плате, као и демографске карактеристике попут структуре становништва и стопа миграције. Са циљем да се обезбиједи комплетност и поузданост података, примијењена је метода вишеструке импутације како би се попуниле недостајуће вриједности. Затим је примијењена PCA ради смањења димензионалности и идентификовања латентних структура у подацима. Добијене главне компоненте су потом коришћене у кластер анализи, што је издвојило четири кластера земаља са сличним профилима тржишта рада.

Резултати анализе потврђују да економски развој и квалитет институција у највећој мјери објашњавају варијабилитет на тржишту рада, при чему демографске варијабле попут старосне структуре и миграција такође имају значајну улогу. Ови налази подржавају хипотезу да се кластери земаља са сличним профилима тржишта рада могу идентификовати користећи економске, демографске и институционалне варијабле. Раздвајање земаља по кластерима додатно омогућава компаративну анализу и истиче регионалне изазове на тржишту рада. За креаторе политика, резултати указују на важност подстицања економске стабилности, унапређења институционалних оквира и креирања циљаних интервенција које узимају у обзир демографску стварност. Такође, будућа истраживања би могла укључити додатне социоекономске димензије и лонгитудиналне податке како би се стекла свеобухватнија слика о кретању свјетског тржишта рада.

Кључне ријечи: *тржиште рада, варијабилитет, анализа главних компоненти.*

IS DIGITALISATION A CATALYST FOR BRICS COUNTRIES' EXPORTS? AN EMPIRICAL ANALYSIS

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ABSTRACT

Digitalisation is a key catalyst which transforms international trade by enhancing efficiency, reducing costs, expanding market access and unlocking new opportunities, significantly boosting export performance. Understanding this interplay is essential for Brazil, Russia, India, China and South Africa (BRICS) countries, major players in global trade. This study examines the digitalisation-exports relationship in BRICS, specifically how Information and Communication Technology (ICT) catalyses exports. Using a combination of panel and country-specific autoregressive distributed lag (ARDL) models, this method captures country heterogeneity and both short-term and long-term dynamics. Panel autoregressive distributed lag identifies common BRICS trends, while country-specific autoregressive distributed lag highlights distinctive country effects, strengthening the analysis. Results show that, in the short term, Information and Communication Technology's effect on exports varies across models. However, in the long term, Information and Communication Technology consistently exerts a statistically significant effect. Findings emphasise digitalisation's pivotal role in enhancing BRICS exports, particularly long term. Yet, effectiveness differs across countries. Disparities in digital infrastructure, digital literacy and institutional quality suggest digitalisation alone is insufficient. Addressing these challenges enables BRICS to leverage digitalisation and strengthen their position as prominent emerging export countries. This study contributes to the digital economy discourse with empirical evidence-based policy implications.

1. INTRODUCTION

The global trade landscape is undergoing rapid transformation driven by the advancement of digital technologies. As digital technologies continue to develop, their integration into various sectors, from manufacturing to financial services, is reshaping traditional trade patterns *(Ahmedov, 2020)*. Digitalisation, encompassing technologies like information and communication technology (ICT), E-commerce, automation, the Internet of Things (IoT), and data analytics, fundamentally reshapes production, consumption, supply chains and global trade dynamics *(Ciuriak, 2020; Ozcan, 2018)*. By enhancing efficiency, reducing costs, facilitating cross-border transactions and expanding market access, digitalisation holds significant potential to boost countries' exports, particularly in developing economies *(Hu et al., 2024; Zare & Persaud, 2024)*.

As prominent players in the global economy, Brazil, Russia, India, China and South Africa (BRICS) countries are actively engaged in this digital revolution. These nations have experienced substantial digital adoption, fuelled by advancements in ICT and increasing internet penetration *(Li, Pogodin & Vasilyeva, 2022)*. For instance, China has emerged as a global leader in E-commerce, with companies like Alibaba and Tencent at the forefront of digital trade and innovation. India has experienced rapid growth in its information technology and software services sector, driven by initiatives such as Digital India *(Fan, 2021)*. Brazil and Russia have also made significant improvements in digitalising their economic sectors, particularly in areas like digital banking and online retail. South Africa, despite facing infrastructural challenges, is expanding its digital services and mobile connectivity *(BRICS Digital Economy Report 2022, 2022)*. Digital technologies empower businesses within these countries to expand their reach globally, connect with international partners and streamline operations, potentially enhancing their export competitiveness and market access *(AL-Khatib, 2023; Ezell & Koester, 2023)*.

Exports are a vital tool for economic development, driving economic growth, generating foreign exchange and creating employment, particularly in developing countries *(Balassa, 1989; Fugazza, 2004)*. In the context of the BRICS countries, digitalisation can enhance export competitiveness and expand access to markets through exposure to the global market *(Martins & Yang, 2009)*. Moreover, robust export performance can attract foreign direct investment (FDI), as investors often seek to capitalise on the export potential of developing markets *(Islam, 2022)* this study aims to investigate the relationship between FDI inflows and export performance in Bangladesh using annual time series data for the period of 1995 to 2020. The empirical analysis is performed employing Johansen cointegration

approach and Vector Error Correction Mechanism (VECM. While extensive research *(Ahmedov, 2020; Freund & Weinhold, 2000; Nath & Liu, 2017; Ozcan, 2018; Wang & Choi, 2018)*, explores digitalisation's broad implications for trade, there is a notable gap in empirically isolating its specific effects on exports, especially within emerging economies like those of the BRICS bloc. Given their diverse economic conditions and varying levels of digital adoption, these countries represent a compelling case for investigating the potential of digitalisation serving as a catalyst for their exports.

Therefore, this study examines the digitalisation-exports relationship within the BRICS context. This analysis is particularly relevant due to the evolving impact of digital technologies on global trade dynamics and provides insights for policymakers aiming to leverage digitalisation to boost exports, particularly in developing countries. The research is motivated by the potentially varied effects of digitalisation across different national contexts due to differences in infrastructure and institutions *(Demin, Mikhaylova & Pyankova, 2023; Saggi, 2002, p. 192)*, and the limited specific study on this relationship within BRICS, despite their rapid digital transformation *(*Li, Pogodin & Vasilyeva, 2022*)*.

The rest of the paper is structured as follows: Section 2 reviews the literature, outlining the theoretical framework and the analysis of empirical studies. Section 3 details the data and methodology. Section 4 presents the results and their interpretations. Section 5 concludes and provides policy implications.

2. LITERATURE REVIEW

2.1 Export patterns in BRICS

As major players in international trade, the BRICS countries collectively account for over 18% of global trade (imports and exports) *(UNCTADstat, 2023)*. This substantial trade volume underscores their growing influence as both producers and consumers, highlighting their importance as key trading partners across various regions. Figure 1 below illustrates a comparative insight into the BRICS countries' total trade (2008 compared to 2021). China's total trade has experienced substantial growth, significantly outpacing its BRICS partners. While India, Russia, and Brazil have also experienced growth, South Africa remains the smallest trade contributor within the group *(Iqbal & Yadav, 2022)*. These trends accentuate the varying trade capacities within the BRICS group and their collective influence on the global trade dynamics *(Nayyar, 2020)*.

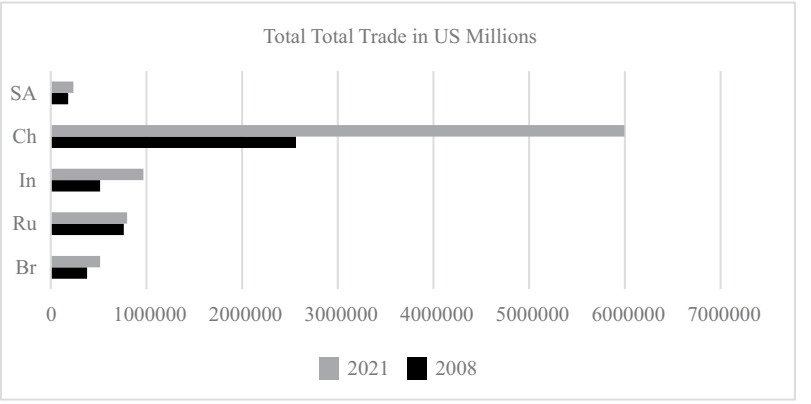

Figure 1. Trade dynamics of BRICS countries: comparative insights (2008 vs. 2021)
Source: Authors' analysis based on data from (UNCTADstat, 2023).

Exports are often influenced by various factors, including foreign demand, commodity prices, and exchange rates. However, the relative importance of these factors varies across countries. In the BRICS countries' context, Brazil's exports are heavily dependent on foreign demand for commodities, whereas China's exports are more diversified and less susceptible to commodity price fluctuations. Russia's exports are influenced by the real effective exchange rate, foreign demand, and commodity prices. India's export performance is similarly linked to the real effective exchange rate and commodity prices, while South Africa's performance is primarily driven by foreign demand *(Hooijmaaijers, 2021)*. In addition, Russia and Brazil have traditionally focused on natural resources such as agriculture and mining, while India and China have excelled in manufactured and processed commodities *(Yarygina et al., 2020)*. Furthermore, tariffs, quotas and other trade barriers can also significantly impact export performance *(Li, Pogodin & Vasilyeva, 2022)*.

The increasing adoption of digital technologies seems to be transforming the trade patterns of BRICS countries. For instance, E-commerce and digital services and payments facilitate cross-border trade and reduce transaction costs *(Barykin et al., 2021)*. Figure 2 below illustrates the growing export volume trends of the BRICS countries over selected years. BRICS countries have different export patterns. For instance, China's dominance in exports is evident, with its share rising from just over 50% in 2000 to 74% in 2020. The different economic conditions and challenges faced by these countries highlight the complexity of their exports and the multidimensional nature of their economic relations.

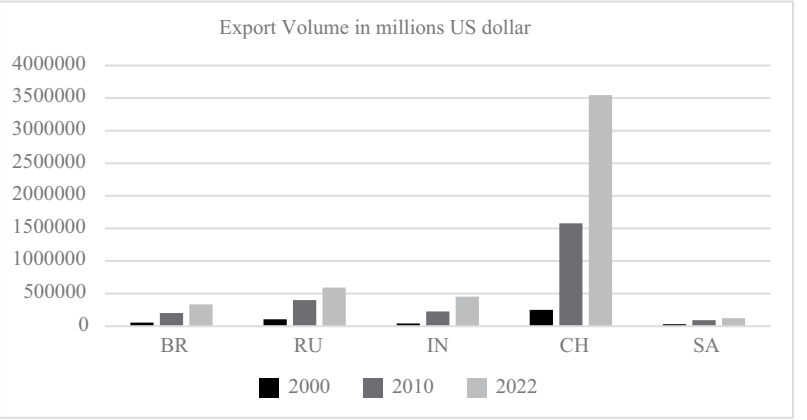

Figure 2. Export volume of BRICS countries over time (2000, 2010 and 2022)
Source: Authors' analysis based on data from (UNCTADstat, 2023).

2.2 Advancements of digitalisation in BRICS countries

Collectively, the BRICS countries account for approximately 30% of global exports of information and communication technology (ICT) products, but only 11% of the global exports of digitally deliverable services *(BRICS Trade in Services Report, 2022)*. Despite China and India's growing prominence as global players in digitally deliverable services, the BRICS countries remain primarily focused on manufacturing or assembling, positioning them at the lower value-added end of the ICT goods value chain *(BRICS Digital Economy Report, 2022)*. This discrepancy stresses the urge for these countries to rise to higher value-added segments within the digital technology sector to fully capitalise on the opportunities presented by digital technologies. Figure 3 below shows the increase in internet users between 2008 and 2021 across BRICS countries. The figure shows substantial growth in connectivity, with Russia and Brazil leading in 2021. Significant growth in internet usage is observed in India and South Africa, driven by the widespread availability of affordable smartphones and mobile data plans. But while South Africa and India are showing significant growth, they still lag in digital connectivity. These disparities in internet penetration are critical to understanding each country's capacity to fully engage in the digital economy. Overall, this increased connectivity in BRICS countries has spurred greater participation in E-commerce and online services. Nonetheless, notable disparities in internet penetration rates persist.

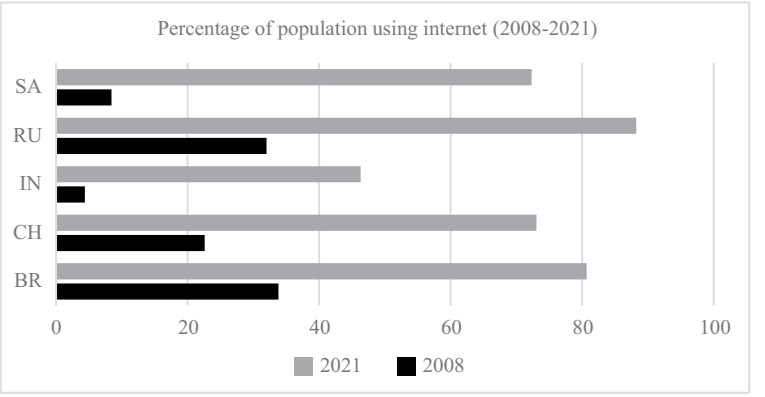

Figure 3. Growth of internet penetration in BRICS countries (2008 vs. 2021)
Source: Authors' analysis based on data from (World Development Indicators | DataBank, 2024).

The growth of the internet penetration in BRICS countries reflects their growing digital infrastructure. For example, Brazil, Russia, and South Africa are investing in enhancing their digital infrastructure, including broadband and 5G technologies, to support faster internet speeds and broader connectivity. China, in particular, is making substantial strides in 5G technology, positioning itself as a leader in digital infrastructure *(BRICS Digital Economy Report 2022, 2022)*. Additionally, initiatives aimed at improving digital literacy such as the Digital India Program and the Digital Saksharta Abhiyan (DISHA) initiative in India, and National Electronic Media Institute of South Africa (NEMISA) under the South Africa's Digital Economy Mission Plan (DEMP) in South Africa, are being implemented to cultivate a workforce capable of effectively utilising digital technologies. These investments are crucial for driving digital transformation, with China setting the pace in both scale and innovation *(Ignatov, 2020)* but at the same time it deepens global inequality and impacts the growth of countries of the global South. The role of global governance institutions such as the BRICS grouping of Brazil, Russia, India, China and South Africa — the main representative of developing countries in global governance — in the promotion of digital growth has not yet been fully explored. There is also some ambiguity concerning the development level of the digital economy in particular countries. In the context of Russia's third BRICS presidency in 2020, issues of digital development in BRICS have become particularly relevant. The author analyzes current indicators of digital development in the BRICS countries, drawing on several existing methodologies, ratings, and decisions made by BRICS on issues of digital growth and levels of compliance, and makes recommendations for the further development of BRICS' digital agenda. According to data provided by the Organisation for Economic Co-operation and Development (OECD.

Moreover, the adoption of digital banking and payment platforms is on the rise across BRICS countries, with India's Unified Payments Interface (UPI) and China's QR code-based transactions leading the way, and with the E-commerce growth, particularly in China and India. Brazil has also seen substantial increases in online shopping activities. There is also a growing emphasis on Artificial Intelligence (AI) use, data analytics and machine learning across BRICS countries, with substantial investments in smart technologies and automation across various sectors, including healthcare, finance and manufacturing *(Li, Pogodin & Vasilyeva, 2022)*. These platforms are significantly increasing financial inclusion. However, the extent to which digital services are available and accessible to citizens and businesses depends on the varying level of digital infrastructure development in each BRICS countries. Figure 4 below displays the ICT infrastructure development index for 2022 for each BRICS country. China and Russia are leading in ICT development. Meanwhile, India, despite its advancements, still requires further development to match the progress of its BRICS. These differences in digital development levels highlight the varying capacities of BRICS countries to harness digital technologies effectively.

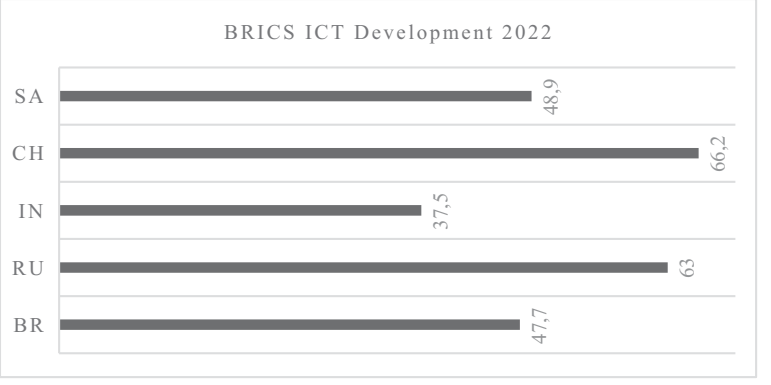

Figure 4. ICT development index across BRICS countries in 2022
Source: Authors' analysis based on data from (UNCTADStat, 2023).

Overall, digitalisation trends in BRICS countries reveal diverse adoption levels, shaped by unique challenges and opportunities. Variations stem from disparities in digital infrastructure, ICT penetration and digital literacy, reflected in indicators like internet connectivity, ICT development and digital skills *(BRICS Digital Economy Report, 2022)*. In addition, factors such as technology investments, regulatory frameworks and access to digital services influence each country's digital progress, affecting their global competitiveness and highlighting the need for tailored digital transformation strategies.

2.3 Conceptual and analytical framework

Economic theories provide valuable insights into how advancements in technology, innovation and human capital contribute to economic growth and international trade. Consequently, the analysis of the digitalisation-exports relationship can be understood through the framework of economic trade theories that explain the effects of digital technologies on international trade. This analysis involves the application of economic theories, including the Endogenous Growth theory *(Romer, 2012; Romer, 1990)* and New Trade theory *(Krugman, 1979)*. These two theoretical frameworks underline the importance of digitalisation in modern trade, especially for emerging economies striving to enhance their export capacity *(Nham, Bao & Ha, 2023, p. 1043)*.

According to the Endogenous Growth theory, technological advancements such as digital infrastructure drive improvements in productivity, which in turn expand trade capacity by lowering production and transaction costs *(Romer, 2012, pp. 102–103)*. This theory suggests that investments in ICT facilitate faster communication and resource optimisation, which are crucial for expanding export markets. Additionally, leveraging digital technologies can enable businesses to improve operational efficiency, facilitate better communication and optimise the allocation of resources, thereby increasing international trade and fostering economic development *(Nham, Bao & Ha, 2023)*. On another hand, the New Trade theory highlights the role of increasing returns to scale and network effects in international trade *(Krugman, 1979)*. Like the Endogenous Growth theory, the New Trade theory focuses on endogenous factors including: the role of technology, increasing returns to scale, knowledge spillovers and human capital *(Chandra, 2022, pp. 221–249)*. However, while this theory highlights the advantages of economies of scale, it often assumes ideal market conditions that may not hold in the real world. For instance, for BRICS countries, factors such as market imperfections, infrastructural deficiencies and regulatory hurdles can obstruct the realisation of these benefits *(Geng et al., 2024)*.

Therefore, in the BRICS countries context, digital technologies can enhance productivity by reducing transaction costs, improving logistics and enabling firms to reach broader markets *(Ignatov, 2020)* While digitalisation can mitigate some of the trade barriers by reducing transaction costs and enhancing market access, the extent of its effectiveness may vary across different economic contexts *(Banga & Kozul-Wright, 2018)*. For instance, in the New Trade theory, a skilled workforce is essential for enhancing a country's competitive advantage in producing high-tech goods for export. This is because high-tech industries often require specialised knowledge and skills, which can drive innovation and

productivity *(Oyelaran-Oyeyinka & Lal, 2005)*. Furthermore, the adoption of E-commerce platforms like eBay, Alibaba and Amazon not only significantly increased global trade volumes but also increased the market opportunities, especially for small and medium enterprises (SMEs) *(Lendle et al., 2016)*. Countries, thus with a more skilled labour force, are better positioned to leverage digital tools and platforms to compete in these sectors and to engage in export activities effectively *(Banga & Kozul-Wright, 2018)*. As BRICS countries continue to increase their digital technologies, they are better positioned to exploit these network effects, particularly in export-oriented sectors.

2.4 Insights from empirical studies

Empirical studies investigating the relationship between digitalisation and trade encompass various strands, including the adoption of the internet and ICT infrastructure *(Añón Higón & Bonvin, 2024; DeStefano & Timmis, 2024)*, E-commerce and the role of digital platforms *(Dethine, Enjolras & Monticolo, 2020; Lendle et al., 2016)*, digital services *(Azar & Ciabuschi, 2017; Liu & Nath, 2013; Nath & Liu, 2017; Yin & Choi, 2024)*, regulatory impacts, and integration into global value chains *(Baldwin, 2017)*. These diverse strands illustrate multifaceted relationships and provide a comprehensive understanding of how digitalisation influences trade and, more specifically, exports.

These empirical studies reveal a spectrum of findings. Using the gravity model in the G20 countries, Yin and Choi (2024) found that digitalisation is more likely to have a positive impact on exports, especially service exports *(Yin & Choi, 2024)*. This study is relevant as it emphasises the impact of digitalisation, specifically on exports. Abendin, Pingfang and Nkukpornu (2022) used the augmented gravity model to capture the effect of digitalisation on bilateral trade in the Economic Community of West African States (ECOWAS). Their findings reveal a significant positive effect of digitalisation on trade in the region *(*Abendin et al., 2022*)*. This study highlights the overall positive impact of digitalisation on trade. Wang and Choi (2018) found that ICT has a more pronounced positive effect on exports than imports within BRICS countries using the gravity model on the panel data from the 2000 to 2016 *(Wang & Choi, 2018)*. This study is most relevant as it is on BRICS countries and highlights the positive expected findings. Ozcan (2018) employed an augmented panel gravity model to investigate the influence of information and communication technologies (ICT) on international trade between Turkey and its trading partners. The findings reveal that ICT exerts a positive and significant impact on both Turkish import and export volumes.

Using a dynamic gravity model on panel data, Rodriguez-Crespo, Marco and Billon (2018) found that the impact of internet use, mobile phones and broadband on bilateral trade flows is greater for the exporter than for the importer. However, the authors emphasised that these impacts vary depending on the type of technology *(Rodriguez-Crespo, Marco & Billon, 2018)*. In Contrast, Ozcan (2018) observes that ICT has a quantitatively greater effect on imports than on exports *(Ozcan, 2018)*. But Liu and Nath (2013) observed that countries with better ICT infrastructure experience higher trade volumes, using fixed effects models of exports and imports with ICT as the main explanatory variable of interest. They highlighted the critical role of digital infrastructure in modern trade dynamics. Once again, the authors accentuated that the trade-enhancing effect of ICT depends more on its effective use than on the mere presence of ICT infrastructure *(*Liu & Nath, 2013*)*. Therefore, based on the above theoretical and empirical literature, this study states the following hypothesis: Null hypothesis*: there is no statistically significant relationship between ICT and exports in BRICS countries.* Alternative hypothesis*: there is a statistically significant relationship between ICT and exports in BRICS countries.*

3. DATA AND METHODOLOGY

This study employs a panel data model and a country-specific autoregressive distributed lag (ARDL) model to examine the short-term and long-term effects of digitalisation on exports in BRICS countries from 2000 to 2022. To distinguish between short-term and long-term effects within the ARDL framework, we concentrate on the coefficients of the lagged differences of the variables to elucidate short-term dynamics. These coefficients signify the immediate effects of variations in the independent variables. In contrast, long-term relationships are represented by the coefficients of the lagged levels of the variables, which denote the equilibrium relationship anticipated to exist in the long-term *(Pesaran & Shin, 1999)*.

The panel ARDL model captures the general dynamics of ICT and other variables' effects on exports across BRICS countries. This approach helps to identify predominant patterns and shared characteristics in the BRICS bloc, allowing for a broad understanding of the factors driving exports in the block and for broader policy implications at a regional level. Given the differences in economic structures, levels of digital infrastructure and trade policies among the BRICS countries, the country-specific ARDL model assesses how ICT affects export in each country differently. This dual approach provides a deeper understanding of country-level variations, informing tailored policy interventions. It also

strengthens the analysis by addressing both the commonalities and differences in how digitalisation impacts exports across BRICS, making the research more robust and policy-relevant.

3.1 Data and sources

Export data and the ICT development index were acquired from the World Development Indicators (WDI) and United Nations Conference on Trade and Development (UNCTAD) databases, respectively. Control variables were sourced from the WDI, UNCTAD and Federal Reserve Economic Data (FRED). Exports (dependent variable) were measured in constant US dollars. The ICT development index (independent variable) included fixed-line and mobile phone penetration, internet usage and secure server availability. To isolate the effect of ICT on exports, control variables included GDP, private sector, exchange rates, inflation, tariffs, human capital and institutional quality. The variables, including human capital, institutional quality, private sector and ICT, are compound indices of the overall productivity capacity index (UNCTADStat, 2023).

Table 1: Summary of Variables, Descriptions and Data Sources

Variables	Description	Sources
ICT	Estimates the accessibility and integration of communication systems within the population. It includes fixed line and mobile phone users, internet accessibility and server security	UNCTAD
Human capital	Captures the education, skills and health conditions possessed by the population, and the overall research and development integration in the texture of society through the number of researchers and expenditure on research activities.	UNCTAD
Institutions	Measures political stability and efficiency through regulatory quality, effectiveness, success in fighting criminality, corruption and terrorism, and safeguarding of citizens' freedom of expression and association.	UNCTAD
Private sector	Defined by the ease of cross-border trade, which includes time and monetary costs to export and import, and the support to business in terms of domestic credit, velocity of contract enforcement and time required to start a business.	UNCTAD
GDP	Gross Domestic Product is used to control for economic size.	WDI
Exchange rate	To account for the relative value of currencies.	UNCTAD and FRED
Inflation	Percentage change in cost to the average consumer	WDI
Tariffs	Tariff rate applied to all products subjected to all traded goods	WDI

Sources: (*FRED, n.d.*; *UNCTADStat, 2023*; *World Development Indicators | DataBank, 2024*).

3.2 Model specification

The ARDL model was selected for its flexibility in accommodating variables with mixed orders of integration (I(0) and I(1)), and its ability to capture both short-term and long-term dynamics in the variables *(Engle & Granger, 1987; Pesaran & Shin, 1999)*. This makes it particularly suited to both time series and panel datasets, where economic variables may exhibit different integration properties *(Bardi & Hfaiedh, 2021)*.

Four panel models were developed to examine the relationship between ICT and export volume while controlling for other relevant variables: Model 1 includes ICT, Human capital and Private sector development; Model 2 includes ICT, GDP and Inflation; Model 3 includes ICT and Institutional quality and Model 4 focuses on ICT, Exchange rate and Tariffs. In addition to the panel models, individual ARDL models were developed for each BRICS country to account for country-specific dynamics. The country-specific models follow a similar ARDL structure, including all variables. We applied the Levin, Lin & Chu and Im, Pesaran and Shin tests to ensure that the variables were either I(0) or I(1), confirming that none were integrated at I(2). To ensure the validity of our results and to confirm the existence of a long-run relationship, we conducted a Bounds Test with F-statistics.

The general specification of the ARDL short and long run (in bold characters) model for t = 1, 2…, T, periods and i = 1, 2, …, N group is specified as follows:

$$\Delta log(EXPORTS_{it}) = \alpha_i + \sum_{j=1}^{p} \beta_{ij} \Delta log(EXPORTS_{i,t-j}) + \sum_{j=0}^{q} \gamma_{ij} \Delta log(ICt_{i,t-j}) + \sum_{j=0}^{r} \delta_{ij} \Delta log(CONTROL_{i,t-j}) + \phi_i (log(EXPORTS_{i,t-1}) - \theta_i \log(ICT_{i,t-1}) - \psi log(CONTROL_{i,t-1}) + \varepsilon_{it}$$

α_i is the country-specific intercept; $\Delta log(EXP_{it})$ is the first difference of the dependent variable (exports); β_{ij}, γ_{ij}, δ_{ij} are the short-run coefficients; ϕ_i is the error correction term that adjusts to the long-run equilibrium; and $log(DIG_{it})$ and $log(CONTROL_{it})$ are logarithms of digitalisation indicators and control variables, respectively. The Error Correction Term (ECT) in the cointegration model measures how quickly deviations from the long-run equilibrium are corrected. A significant speed of adjustment suggests that the dependent variable responds strongly to changes in the independent variables. For example, the ECT captures the speed at which exports adjust to changes in ICT. The ECT is expected to have a negative sign and be statistically significant. A negative and significant ECT confirms that the system corrects deviations from the long-run equilibrium

in a predictable way *(Engle & Granger, 1987; Pesaran & Shin, 1999)*. Below are the estimation techniques with exports as the dependent variable in all four equations.

Model 1 (ICT, Human capital, Private sector development):

$$\begin{aligned}\Delta \log(EXPORTS_{it}) = {} & \alpha_i + \sum_{j=1}^{p} \beta_{ij} \Delta \log(EXPORTS_{i,t-j}) + \sum_{j=0}^{q} \gamma_{ij} \Delta \log(ICT_{i,t-j}) \\ & + \sum_{j=0}^{q} \mu_{ij} \Delta \log(HC_{i,t-j}) + \sum_{j=0}^{q} \mu_{ij} \Delta \log(PRIVATESECT_{i,t-j}) \\ & + \phi_i (\log(EXPORTS_{i,t-1}) + \theta_i \log(ICT_{i,t-1}) + \psi \log(HC_{i,t-1}) \\ & + \psi \log(PRIVATESECT_{i,t-1}) + \varepsilon_{it}\end{aligned}$$

Model 2 (ICT, GDP, Inflation):

$$\begin{aligned}\Delta \log(EXPORTS_{it}) = {} & \alpha_i + \sum_{j=1}^{p} \beta_{ij} \Delta \log(EXPORTS_{i,t-j}) + \sum_{j=0}^{q} \gamma_{ij} \Delta \log(ICT_{i,t-j}) \\ & + \sum_{j=0}^{q} \mu_{ij} \Delta \log(GDP_{i,t-j}) + \sum_{j=0}^{q} \mu_{ij} \Delta \log(INFL_{i,t-j}) \\ & + \phi_i (\log(EXPORTS_{i,t-1}) + \theta_i \log(ICT_{i,t-1}) + \psi \log(GDP_{i,t-1}) \\ & + \psi \log(INFL_{i,t-1}) + \varepsilon_{it}\end{aligned}$$

Model 3 (ICT, Institutions):

$$\begin{aligned}\Delta log(EXPORTS_{it}) = {} & \alpha_i + \sum_{j=1}^{p} \beta_{ij} \Delta \log(EXPORTS_{i,t-j}) + \sum_{j=0}^{q} \gamma_{ij} \Delta \log(ICT_{i,t-j}) \\ & + \sum_{j=0}^{q} \mu_{ij} \Delta \log(INSTITUTIONS) + \phi_i \log(EXPORTS_{i,t-1}) \\ & + \theta_i \log(ICT_{i,t-1}) + \psi \log(INSTITUTIONS_{i,t-1}) + \varepsilon_{it}\end{aligned}$$

Model 4 (ICT, Exchange rate and Tariffs):

$$\begin{aligned}\Delta log(EXPORTS_{it}) = {} & \alpha_i + \sum_{j=1}^{p} \beta_{ij} \Delta \log(EXPORTS_{i,t-j}) + \sum_{j=0}^{q} \gamma_{ij} \Delta \log(ICT_{i,t-j}) \\ & + \sum_{j=0}^{q} \mu_{ij} \Delta \log(EXCH\_R_{i,t-j}) + \sum_{j=0}^{q} \mu_{ij} \Delta \log(TARIFFS_{i,t-j}) \\ & + \phi_i \log(EXPORTS_{i,t-1}) + \theta_i \log(ICT_{i,t-1}) + \psi \log(EXCH\_R_{i,t-1}) \\ & + \psi \log(TARIFFS_{i,t-1}) + \varepsilon_{it}\end{aligned}$$

4. RESULTS AND DISCUSSIONS

4.1 Unit Root Tests

Table 2 below presents the stationary test result. The Levin, Lin & Chu Test confirmed that the variables were stationary at I(0) (stationary at their level) and I(1) (integrated of order 1), which supported the use of the ARDL model.

Table 2: Result of Unit Root Analysis via Levin, Lin & Chu Test

Variables	Probability	Integrated order
LEXPORTS	0.0000***	I (0)
LICT	0.0000***	I (0)
D(LHC)	0.0025***	I (1)
D(LPRIVATESECT)	0.0000***	I (1)
D(LINSTITUTIONS)	0.0000***	I (1)
INFL	0.0013***	I (0)
D(LEXCH_R)	0.0000***	I (1)
D(GDP)	0.0000***	I (1)
TARIFFS	0.0001***	I (0)

Note: * significant at 10% level, ** significant at 5% level and *** significant at 1% level.

Source: Authors' analysis.

4.2 Panel ARDL results and discussion

Table 3 below presents the (short-run and long-run) estimation results from the panel ARDL model. The results indicated a statistically significant and positive relationship between ICT and exports in BRICS countries in both the short run and long run, except for model 2, which only showed statistical significance in the long run. In model 2, ICT had a statistically significant and positive relationship with exports in the long run at the 1% level, but it was statistically insignificant and positive in the short run. This implies the lag in realising improvements from digital infrastructure, as ICT infrastructure projects typically take time to become fully operational, leading to delayed influence on trade flows. The significant short-run gains in exports in other models likely reflect the rapid uptake of digital technologies and E-commerce platforms, which can quickly facilitate trade by reducing transaction costs and improving global market access. This suggests that investments in digital infrastructure are crucial across both time horizons. Overall, these findings suggest that digitalisation plays a critical role in enhancing export performance, which is consistent with previous empirical studies like *(Liu & Nath, 2013; Rodriguez-Crespo et al., 2018; Wang & Choi, 2018; Yin & Choi, 2024)* that find that ICT has a positive effect on exports. The error correction term (ECM) was statistically significant across all models.

For instance, the coefficients in Model 1 were -0.3208 and -0.0815 in Model 4, significant at the 1% level (p=0.0018 and p=0.0223, respectively). The ECM results suggest a relatively fast adjustment process from any deviations from long-run equilibrium.

Table 3: Panel ARDL short-run and long-run estimations

SHORT-RUN (MEAN-GROUP)					
MODELS	COINTEQ (ECM)		VARIABLES		
	Coefficient	Prob.		Coefficient	Prob.
Model 1	-0.3208	0.0018**	D(LICT)	1.0450	0.0957*
			D(LHC)	-9.605060	0.0621*
			D(LPRIVATESECT)	0.832368	0.3977
Model 2	-0.1393	0.0407**	D(LICT)	0.070059	0.9069
			D(GDP)	0.017882	0.0064***
			D(INFL)	-0.001795	0.8455
Model 3	-0.1192	0.0548**	D(LICT)	1.2280	0.0000***
Model 4	-0.0815	0.0223**	D(LICT)	0.837426	0.0000***
			D(LEXCH_R)	-1.126824	0.0000***
			D(LTARIFFS)	0.040153	0.8503

LONG-RUN (POOLED)			
MODELS	VARIABLES	Coefficient	Prob.
Model 1	LICT	2.061717	0.0000***
	LHC	-1.465710	0.0000***
	LPRIVATESECT	-1.356958	0.0000***
Model 2	LICT	1.942462	0.0000***
	GDP	0.154894	0.0000***
	INFL	0.082354	0.0009***
Model 3	LICT	1.126552	0.0000***
	LINSTITUTIONS	1.335899	0.3206
Model 4	LICT	0.857749	0.0842*
	LEXCH_R	1.447625	0.0027***
	LTARIFFS	-0.946107	0.1821

Note: * significant at 10% level, ** significant at 5% level and *** significant at 1% level.

Source: Authors' calculation

Among the other variables in the analysis, only GDP had a statistically significant and positive relationship with exports in both the short and long run at the 1% level of significance. Notably, these results of GDP suggest that short-term and long-term changes in economic growth have an immediate effect on exports, reinforcing that economic growth contributes to export capacity, as highlighted by various scholars *(Bhattacharya & Bhattacharya, 2016; Palamalai, 2016; Ramakgasha, Gidi & Thaba, 2023)*.

The negative and statistically significant exchange rate suggests that a weak currency constrains exports in the short run but boosts exports in the long run by making goods more affordable in international markets. It was counterintuitive

that human capital investment has a negative relationship with exports, as one would expect that human capital in the form of skills should contribute towards export promotion. However, this finding suggests a possibility of skill mismatch, implying inefficiencies or mismatches in skills despite digital technologies advancements in BRICS countries, as the skills provided are not relevant to the export sectors. In BRICS countries, where exports are often dominated by manufacturing and natural resource industries, excessive investment in skills not directly relevant to those sectors might lead to inefficiencies. In addition, in BRICS countries, highly skilled workers may emigrate to countries with higher wages, reducing the positive impact of human capital investment on the economy. The negative relationship between human capital investment and exports in BRICS countries could also be due to several structural and economic dynamics, such as sectoral mismatches, resource dependency and institutional factors *(Becker, 1964; Lucas, 1988)*. These factors might prevent human capital from translating into improved export performance.

The positive and statistically significant coefficient of inflation in the long run may also seem counterintuitive, as the result implies that high inflation weakens the currency, which boosts exports. But countries rich in natural resources often export goods that exhibit relatively inelastic demand in global markets. For instance, Brazil, known for its agricultural exports, and Russia, a major energy exporter, may experience domestic inflation. However, due to the inelastic global demand for these commodities, their exports can continue to grow despite higher domestic inflation. This phenomenon can create a long-term positive relationship between inflation and exports. In BRICS countries, this result of the relationship between inflation and exports reflects underlying economic dynamics such as industrialisation, export diversification and global commodity price trends. These factors can ultimately enhance export performance despite inflationary pressures *(Arezki & Brückner, 2011)*. Finally, the statistically insignificant relationship between tariffs and exports could be attributed to a variety of factors, including the resilience and adaptability of exporters, global value chain integration, trade agreements, non-tariff barriers and offsetting effects in production costs and export competitiveness. These factors can dilute the impact of tariffs on exports, especially in complex economies like those of the BRICS countries.

4.3 Country-specific ARDL results and discussion

Tables 4 to 8 below present the country-specific ARDL results. Here, we only focused on interpreting and discussing the ICT relationship result estimations for exports for each of the BRICS countries. Overall, the country-specific ARDL results indicate variations in the role of ICT in supporting exports across the

BRICS nations. In China (Table 7) and Russia (Table 5), ICT shows a statistically significant positive relationship with exports, an unexpected statistically significant negative relationship in Brazil (Table 4), while demonstrating a delayed impact in India (Table 6) and minimal relevance in South Africa (Table 8). These varied outcomes reflect how each country's distinct economic structure, sectoral composition and stage of ICT adoption interact with digitalisation's influence on export dynamics. The error correction terms were statistically significant, indicating a rapid adjustment to long-run equilibrium.

Table 4: Brazil's ARDL short-run and long-run estimations

Dependent Variable: LEXPORTS				
Method: ARDL				
Automatic-lag linear regressors (1 max. lags): LICT LHC LINSTITUTIONS LPRIVATESECT GDP EXCH_R INFL TARRIFS				
Model selection method: Akaike info criterion (AIC)				
Selected model: ARDL(1,1,0,0,1,0,0,0,0)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LEXPORTS(-1)	0.513349	0.095218	5.391324	0.0003
LICT	-1.060038	0.482925	-2.195036	0.0529**
LICT(-1)	0.826209	0.395475	2.089156	0.0632*
LHC	-1.626538	1.165307	-1.395803	0.1930
LINSTITUTIONS	-2.551503	0.925638	-2.756481	0.0203**
LPRIVATESECT	2.033313	0.931377	2.183125	0.0540**
LPRIVATESECT(-1)	1.641819	0.668021	2.457737	0.0338**
GDP	0.046800	0.007361	6.357914	0.0001***
EXCH_R	-0.065639	0.042025	-1.561886	0.1494
INFL	0.030690	0.007575	4.051373	0.0023**
TARIFFS	-0.085190	0.036834	-2.312794	0.0433**
C	10.85143	5.094650	2.129966	0.0590
Error Correction Test				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ*	-0.486651	0.030260	-16.08243	0.0000***
D(LICT)	-1.060038	0.184953	-5.731379	0.0000***
D(LPRIVATESECT)	2.033313	0.363398	5.595279	0.0000***
Bounds Test				
Null hypothesis: No levels relationship				
Test Statistic	Value			
F-statistic	13.612864			
	10%		5%		1%	
Sample Size	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
30	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
Asymptotic	1.850	2.850	2.110	3.150	2.620	3.770

Note: * significant at 10% level, ** significant at 5% level and *** significant at 1% level.

Source: Authors' calculation.

To confirm the presence of a long-run relationship (cointegration) among the variables in each country-specific ARDL model, the Bounds Test was conducted. The Null Hypothesis for this test is "No level relationship". The test statistic (F-statistic) is compared against critical values to assess statistical significance. The Bounds Test F-statistic results for Brazil (13.61), Russia (12.87), India (3.76) and China (17.72) suggest evidence of a long-run relationship among the variables in the model at a 10% critical value for Brazil, Russia, India and China. Therefore, we rejected the null hypothesis and confirmed there is level relationship between ICT and exports in the BRICS countries above.

The results in Table 4 above for Brazil exhibited a statistically significant negative relationship between ICT and exports, the short run (1% significance level). However, a positive and statistically significant relationship was observed between lagged ICT and long-run exports at the 10% significance level. The short-run negative relationship between concurrent ICT and exports indicates that, contrary to expectations, ICT does not immediately stimulate Brazil's exports. This finding is particularly relevant for Brazil, as noted, Brazil's primary sectors are agriculture and mining, which may not fully capitalise on digital tools or ICT investments in the short run *(McFadden et al., 2022, pp. 9, 20, 25, 32–34; Oyelami, Sofoluwe & Ajeigbe, 2022)*. Given the slower adoption rates of digitalisation in the agricultural sector, it suggests that significant time and targeted application of ICT are required to observe measurable improvements in exports. Moreover, agricultural exports may rely more on other factors, such as climate, trade policies and commodity demand, than on ICT directly. The positive impact of lagged ICT on long-run exports implies that past ICT investments or improvements have a delayed, positive effect on exports. This time lag may be attributed to the time required for firms to adapt digital tools to their specific production processes, particularly in traditional sectors like agriculture. It indicates that while current digitalisation development may not immediately translate to export growth, prior investments in digital infrastructure or technologies could yield export-related benefits over time *(Tadesse & Badiane, 2018)*. This nuanced relationship implies that for Brazil, strategic and tailored digitalisation initiatives may need to account for sector-specific requirements and lagged effects of ICT adoption to maximise exports' long-term growth.

Tables 5 and 6 below display ARDL results for Russia and India, respectively. The results for Russia in Table 5 showed that ICT had a statistically significant positive relationship with exports at the 5% significance level in the long run. This implies that Russia's ICT infrastructure and investment are effectively enhancing exports. Russia's export composition includes a significant portion of energy and heavy industrial products, where ICT could enhance processes

such as logistics, supply chain management and quality control *(Feiguine & Solovjova, 2014)*. The infrastructure developed within ICT might also streamline complex export procedures, from compliance to international communication, aiding export effectiveness.

Table 5: Russia's ARDL short-run and long-run estimations

Dependent Variable: LEXPORTS
Method: ARDL
Automatic-lag linear regressors (1 max. lags): LICT LHC LINSTITUTIONS LPRIVATESECT GDP LEX_R LINFL TARRIFS
Model selection method: Akaike info criterion (AIC)
Selected model: ARDL(1,0,0,1,1,0,0,0,0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LEXPORTS(-1)	-0.140791	0.270353	-0.520766	0.6139
LICT	0.764838	0.278064	2.750583	0.0205**
LHC	2.661791	2.663937	0.999194	0.3413
LINSTITUTIONS	-0.468985	1.143778	-0.410032	0.6904
LINSTITUTIONS(-1)	-1.999373	1.200221	-1.665837	0.1267
LPRIVATESECT	1.592876	1.581020	1.007499	0.3375
LPRIVATESECT(-1)	2.716190	1.702608	1.595311	0.1417
GDP	0.016602	0.009814	1.691709	0.1216
LEX_R	-0.583772	0.252012	-2.316440	0.0430**
LINFL	0.128913	0.100268	1.285690	0.2275
TARIFFS	0.023091	0.009457	2.441676	0.0347**
C	-4.626263	7.809464	-0.592392	0.5667

Error Correction Test
Automatic-lag linear regressors (1 max. lags): LICT LHC LINSTITUTIONS LPRIVATESECT GDP LEX_R LINFL TARRIFS
Model selection method: Akaike info criterion (AIC)
Selected model: ARDL (1,0,0,1,1,0,0,0,0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ*	-1.140791	0.072947	-15.63864	0.0000***
D(LINSTITUTIONS)	-0.468985	0.478440	-0.980238	0.3393
D(LPRIVATESECT)	1.592876	0.328923	4.842707	0.0001***

Bounds Test
Null hypothesis: No levels relationship

Test Statistic	Value
F-statistic	12.871958

	10%		5%		1%	
Sample Size	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
30	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
Asymptotic	1.850	2.850	2.110	3.150	2.620	3.770

Note: * significant at 10% level, ** significant at 5% level and *** significant at 1% level.
Source: Authors' analysis.

The results for India in Table 6 showed that ICT had mixed impacts on exports. The ICT and exports relationship only became statistically significant and positive in the long term after lagging ICT at a 10% level. This suggests that digitalisation might take time to positively impact exports in India. The delayed positive effect of ICT on exports in India suggests that while ICT investments do contribute positively to exports, the results take time to manifest. This lag might indicate that ICT initiatives in India are initially focused on developing infrastructure or enabling sectors indirectly linked to exports. Moreover, India's economy relies heavily on services exports (e.g., IT and software services), which are naturally aligned with ICT advancements. However, in the manufacturing and agriculture sectors, the adoption of ICT may take longer to yield visible results, as shown for Brazil. Additionally, India's ICT sector investments might need to mature and integrate better with export-related activities, leading to the observed time lag *(BRICS Trade in Services Report, 2022)*.

Table 6: India's ARDL short-run and long-run estimations

Dependent Variable: LEXPORTS				
Method: ARDL				
Automatic-lag linear regressors (1 max. lags): LICT LHC LINSTITUTIONS LPRIVATESECT GDP EXCH_R INFL TARRIFS				
Model selection method: Akaike info criterion (AIC)				
Selected model: ARDL(1,1,0,0,1,0,0,0,1)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LEXPORTS(-1)	0.228448	0.298773	0.764621	0.4641
LICT	-0.383852	1.035287	-0.370769	0.7194
LICT(-1)	1.930579	0.964296	2.002061	0.0763*
LHC	3.792977	2.060140	1.841126	0.0987*
LINSTITUTIONS	-2.922411	3.148599	-0.928163	0.3775
LINSTITUTIONS(-1)	3.628506	2.768285	1.310742	0.2224
LPRIVATESECT	-0.207899	2.353683	-0.088329	0.9315
GDP	0.021771	0.008719	2.496946	0.0340**
INFL	0.005824	0.024248	0.240167	0.8156
LEXCH_R	-2.313551	0.517763	-4.468361	0.0016***
TARIFFS	-0.004816	0.013828	-0.348300	0.7356
TARIFFS(-1)	0.020997	0.012991	1.616230	0.1405
C	-1.569542	9.018618	-0.174034	0.8657
Error Correction Test				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ*	-0.771552	0.088989	-8.670208	0.0000***
D(INSTITUTIONS)	2.922411	0.852162	-3.429408	0.0030***

Bounds Test						
Null hypothesis: No level relationship						
Test Statistic	Value					
F-statistic	3.758626					
	10%		5%		1%	
Sample Size	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
30	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
Asymptotic	1.850	2.850	2.110	3.150	2.620	3.770

Note: * significant at 10% level, ** significant at 5% level and *** significant at 1% level.

Source: Authors' analysis.

In Table 7 below, the results show that in China, ICT exhibits a statistically significant and positive relationship with exports at the 5% level in the long run. The positive and significant impact of ICT on exports underscores that digitalisation is directly enhancing China's export performance. This alignment indicates that China's export economy, which spans a broad range of goods including electronics, machinery and textiles, is highly compatible with the benefits that ICT provides. China's emphasis on digitalisation, smart manufacturing and e-commerce has likely allowed for rapid ICT adoption across its export sectors.

Table 7: China's ARDL short-run and long-run estimations

Dependent Variable: LEXPORTS				
Method: ARDL				
Automatic-lag linear regressors (1 max. lags): LICT LHC LINSTITUTIONS LPRIVATESECT GDP EXCH_R INFL TARRIFS				
Model selection method: Akaike info criterion (AIC)				
Selected model: ARDL(1,0,1,1,1,0,0,1,0)				
Variables	Coefficient	Std. Error	t-Statistic	Prob.
LEXPORTS(-1)	0.174250	0.116266	1.498718	0.1723
LICT	1.082189	0.342348	3.161074	0.0134**
LHC	-1.393979	2.344757	-0.594509	0.5686
LHC(-1)	5.492890	2.029244	2.706866	0.0268**
LINSTITUTIONS	-2.431860	0.932292	-2.608474	0.0312**
LINSTITUTIONS(-1)	-0.756468	0.590315	-1.281466	0.2359
LPRIVATESECT	0.701549	0.622655	1.126705	0.2925
LPRIVATESECT(-1)	-1.393935	0.799108	-1.744365	0.1193
GDP	0.011089	0.008673	1.278608	0.2369
TARRIFS	0.036275	0.017384	2.086715	0.0704*
INFL	0.018526	0.007152	2.590316	0.0321**
EXCH_R	-0.198102	0.096183	-2.059638	0.0734*
EXCH_R(-1)	0.292542	0.106952	2.735248	0.0256**
C	5.598956	2.645828	2.116145	0.0672

Error Correction Test				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ*	-0.825750	0.042548	-19.40760	0.0000***
D(LHC)	-1.393979	0.513295	-2.715749	0.0147**
D(LINSTITUTIONS)	-2.431860	0.268269	-9.065016	0.0000***
D(LPRIVATESECT)	0.701549	0.304324	2.305271	0.0340**
D(EXCH_R)	-0.198102	0.023015	-8.607377	0.0000***

Bounds Test	
Null hypothesis: No levels relationship	
Test Statistic	Value
F-statistic	17.724942

	10%		5%		1%	
Sample Size	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
30	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
Asymptotic	1.850	2.850	2.110	3.150	2.620	3.770

Note: * significant at 10% level, ** significant at 5% level and *** significant at 1% level.

Source: Authors' analysis.

Table 8: South Africa's ARDL short-run and long-run estimations

Dependent Variable: LEXPORTS				
Method: ARDL				
Automatic-lag linear regressors (1 max. lags): LICT LHC LINSTITUTIONS LPRIVATESECT GDP EXCH_R INFL TARRIFS				
Model selection method: Akaike info criterion (AIC)				
Selected model: ARDL(1,1,1,1,1,1,0,1,1)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LEXPORTS(-1)	-0.171898	0.554842	-0.309815	0.7692
LICT	-0.373697	1.125031	-0.332166	0.7532
LICT(-1)	0.863665	1.041208	0.829483	0.4446
LHC	1.995710	9.312787	0.214298	0.8388
LHC(-1)	-8.831214	8.684240	-1.016924	0.3558
LINSTITUTIONS	-5.776736	2.627844	-2.198279	0.0793*
LINSTITUTIONS(-1)	-5.054271	3.866821	-1.307087	0.2481
LPRIVATESECTOR	-0.291148	3.210304	-0.090692	0.9313
LPRIVATESECTOR(-1)	4.754227	4.233074	1.123115	0.3124
GDP	-0.052744	0.051044	-1.033318	0.3488
GDP(-1)	-0.065487	0.023133	-2.830873	0.0366**
EXCH_R	-0.087971	0.047679	-1.845072	0.1243
INFL	0.034235	0.037857	0.904307	0.4073
INFL(-1)	-0.076829	0.046801	-1.641621	0.1616
TARRIFS	0.061042	0.077712	0.785485	0.4677
TARRIFS(-1)	-0.231007	0.166329	-1.388854	0.2236
C	65.29742	23.36734	2.794388	0.0382

Error Correction Test				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ*	-1.171898	0.152184	-7.700527	0.0000***
D(LINSTITUTIONS)	-5.776736	0.865771	-6.672358	0.0000***
D(GDP)	-0.052744	0.011854	-4.449388	0.0006***
D(INFL)	0.034235	0.009404	3.640406	0.0027***

Bounds Test	
Null hypothesis: No levels relationship	
Test Statistic	Value
F-statistic	2.117790

	10%		5%		1%	
Sample Size	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
30	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
Asymptotic	1.850	2.850	2.110	3.150	2.620	3.770

Note: * significant at 10% level, ** significant at 5% level and *** significant at 1% level.

Source: Authors' analysis.

In Table 8 above, the results of South Africa (SA) show that both current and lagged ICT had a statistically insignificant relationship with SA's exports. This insignificant relationship between ICT and exports suggests that digitalisation adoption is not translated into export performance. This implies that either ICT adoption in export-related sectors is limited, or that ICT initiatives are not well-aligned with the needs of the export sector. This can be attributed to several factors, including the relatively low adoption of advanced ICT across different sectors, varying levels of infrastructure development and the influence of other more dominant economic factors *(Gono, Harindranath & Berna Özcan, 2016)*. SA's exports are largely resource-based, such as mining and agriculture, which traditionally benefit less from digitalisation compared to the manufacturing or services sectors. Moreover, infrastructural and economic challenges in ICT adoption across industries may limit the export benefits of ICT, as the technology may not yet be sufficiently developed or applied to enhance resource-based exports. Additionally, challenges such as skills shortages, economic disparities and market saturation can contribute to the disconnect between ICT development and export performance *(Van Der Walt et al., 2016)*.

Overall, key findings indicate that digitalisation serves as a crucial long-term catalyst for BRICS exports. However, its effects vary significantly across these prominent economies. Recognising these country-specific differences is essential for implementing effective strategies.

5. CONCLUSIONS AND POLICY IMPLICATIONS

This study examined the relationship between digitalisation and exports in BRICS countries from 2000 to 2022, using panel and country-specific ARDL models to capture both common and specific country dynamics between digitalisation and exports. This dual approach provided a comprehensive framework for understanding the varied effects of digitalisation on exports and offered insights for policymakers. The panel ARDL approach helped to identify primary patterns and shared characteristics within the BRICS bloc, allowing for broader policy implications at a regional level. Meanwhile, the country-specific ARDL approach provided a deeper understanding of country-level variations, informing tailored policy interventions.

Key findings indicated a mixed short-run impact of Information and Communication Technology (ICT) on exports across different model specifications. However, overall, in the long run, ICT consistently showed a statistically significant positive effect on export across BRICS countries. Importantly, the effect of digitalisation acting as a catalyst in these countries varies significantly by country, with empirical results showing the strongest gains in China. These findings underscore that while digital infrastructure is a vital component, maximising the trade benefits of digitalisation necessitates complementary policies focused on enhancing human capital and institutional quality. Despite existing challenges such as varying levels of digital maturity within the group, digitalisation broadly acts as a catalyst for BRICS exports by improving trade efficiency and facilitating digital trade. The country-specific results emphasise the necessity of tailored policy approaches. For instance, Brazil could prioritise investments in ICT infrastructure and institutional reforms, while China might focus on consolidating digital trade networks and managing exchange rate volatility. Based on the findings, key policy implications for BRICS countries include:

- Prioritising investment in and development of ICT infrastructure, enhancing internet connectivity and promoting ICT adoption in export-oriented sectors.
- Focusing on human capital development through improved digital literacy and aligning educational outcomes with the demands of the digital economy.
- Implementing targeted interventions to better align specific economic sectors with export growth strategies.
- Streamlining the regulatory environment to reduce trade barriers and enable businesses to leverage digital technologies effectively for export expansion.

By addressing these areas, BRICS countries can harness the full potential of digitalisation to enhance exports and contribute to sustained economic growth. The process of digitalisation presents a significant opportunity for enhancing export growth for BRICS. However, it is not a panacea. Our findings have provided direct, evidence-driven guidance for policymakers, emphasising the importance of investing in digital infrastructure alongside essential complementary elements such as skill development and institutional frameworks to effectively unlock export capabilities.

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Conflict of interest

The authors declare there is no conflict of interest.

REFERENCES

Abendin, S., Pingfang, D., & Nkukpornu, E. (2022). Bilateral Trade in West Africa: Does Digitalization Matter? *The International Trade Journal*, *36*(6), 477–501. https://doi.org/10.1080/08853908.2021.2015488

Ahmedov, I. (2020). The Impact of Digital Economy on International Trade. *European Journal of Business and Management Research*, *5*(4). https://doi.org/10.24018/ejbmr.2020.5.4.389

AL-Khatib, A. W. (2023). The determinants of export performance in the digital transformation era: Empirical evidence from manufacturing firms. *International Journal of Emerging Markets*. https://doi.org/10.1108/IJOEM-08-2022-1223

Añón Higón, D., & Bonvin, D. (2024). Digitalization and trade participation of SMEs. *Small Business Economics*, *62*(3), 857–877. https://doi.org/10.1007/s11187-023-00799-7

Arezki, R., & Brückner, M. (2011). Oil rents, corruption, and state stability: Evidence from panel data regressions. *European Economic Review*, *55*(7), 955–963. https://doi.org/10.1016/j.euroecorev.2011.03.004

Azar, G., & Ciabuschi, F. (2017). Organizational innovation, technological innovation, and export performance: The effects of innovation radicalness and extensiveness. *International Business Review*, *26*(2), 324–336. https://doi.org/10.1016/j.ibusrev.2016.09.002

Balassa, B. (1989). The Importance of Trade for Developing Countries. In B. Balassa, *New Directions in the World Economy* (pp. 3–31). Palgrave Macmillan UK. https://doi.org/10.1007/978-1-349-10588-5_1

Baldwin, R. (2017). *The Great Convergence: Information Technology and the New Globalization*. Harvard University Press. https://doi.org/10.4159/9780674972667

Banga, R., & Kozul-Wright, R. (2018). *South-South Digital Cooperation for Industrialization: A Regional Integration Agenda*. United Nations Conference on Trade and Development (UNCTAD). https://unctad.org/system/files/official-document/gdsecidc2018d1_en.pdf

Bardi, W., & Hfaiedh, M. A. (2021). International trade and economic growth: Evidence from a panel ARDL-PMG approach. *International Economics and Economic Policy*, *18*(4), 847–868. https://doi.org/10.1007/s10368-021-00507-4

Barykin, S. E., Kapustina, I. V., Korchagina, E. V., Sergeev, S. M., Yadykin, V. K., Abdimomynova, A., & Stepanova, D. (2021). Digital Logistics Platforms in the BRICS Countries: Comparative Analysis and Development Prospects. *Sustainability*, *13*(20), 11228. https://doi.org/10.3390/su132011228

Becker, G. S. (1964). *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education* (SSRN Scholarly Paper 1496221). https://papers.ssrn.com/abstract=1496221

Bhattacharya, M., & Bhattacharya, S. N. (2016). International Trade and Economic Growth: Evidences From The Brics. *Journal of Applied Economics and Business Research*, *6*(2), 150–160. http://www.aebrjournal.org/uploads/6/6/2/2/6622240/joaebrjune2016_150_160.pdf

BRICS Digital Economy Report. (2022). International Trade Center (ITC). https://intracen.org/resources/publications/brics-digital-economy-2022

BRICS Trade in Services Report 2022 (TFPB-22-52). (2022). International Trade Center (ITC). https://intracen.org/resources/publications/brics-trade-in-services-report-2022

Chandra, R. (2022). Paul Krugman, New Trade Theory and New Economic Geography. In R. Chandra, *Endogenous Growth in Historical Perspective* (pp. 221–249). Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-83761-7_8

Ciuriak, D. (2020). Digital Trade in a Post-Pandemic Data-Driven Economy. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3617251

Demin, S., Mikhaylova, A., & Pyankova, S. (2023). Digitalization and its impact on regional economy transformation mechanisms. *International Journal of System Assurance Engineering and Management*, *14*(1), 377–390. https://doi.org/10.1007/s13198-022-01806-y

DeStefano, T., & Timmis, J. (2024). Robots and export quality. *Journal of Development Economics*, *168*, 103248. https://doi.org/10.1016/j.jdeveco.2023.103248

Dethine, B., Enjolras, M., & Monticolo, D. (2020). Digitalization and SMEs' Export Management: Impacts on Resources and Capabilities. *Technology Innovation Management Review*, *10*(4), 18–34. https://doi.org/10.22215/timreview/1344

Engle, R. F., & Granger, C. W. J. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing. *Econometrica*, *55*(2), 251–176. https://doi.org/10.2307/1913236

Ezell, S., & Koester, S. (2023). *Transforming Global Trade and Development With Digital Technologies* [White Paper]. Information Technology and Innovation Foundation (ITIF). https://itif.org/publications/2023/05/08/transforming-global-trade-and-development-with-digital-technologies/

Fan, X. (2021). Digital Economy Development, International Trade Efficiency and Trade Uncertainty. *China Finance and Economic Review*, *10*(3), 89–110. https://doi.org/10.1515/cfer-2021-0018

Federal Reserve Economic Data | FRED | St. Louis Fed. (n.d.). Federal Reserve Economic Data. https://fred.stlouisfed.org/

Feiguine, G., & Solovjova, J. (2014). ICT investment and internationalization of the Russian economy. *International Economics and Economic Policy*, *11*(1–2), 231–250. https://doi.org/10.1007/s10368-013-0256-5

Freund, C. L., & Weinhold, D. (2000). The effect of the Internet on international trade. *Journal of International Economics*, *62*(1), 171–189. https://doi.org/10.1016/S0022-1996(03)00059-X

Fugazza, M. (with United Nations Conference on Trade and Development). (2004). *Export performance and its determinants: Supply and demand constraints*. United Nations. https://unctad.org/system/files/official-document/itcdtab27_en.pdf

Geng, W., Liu, L., Zhao, J., Kang, X., & Wang, W. (2024). Digital Technologies Adoption and Economic Benefits in Agriculture: A Mixed-Methods Approach. *Sustainability*, *16*(11), 4431. https://doi.org/10.3390/su16114431

Gono, S., Harindranath, G., & Berna Özcan, G. (2016). The Adoption and Impact of ICT in South African SMEs. *Strategic Change*, *25*(6), 717–734. https://doi.org/10.1002/jsc.2103

Hooijmaaijers, B. (2021). The BRICS Countries' Bilateral Economic Relations, 2009 to 2019: Between Rhetoric and Reality. *SAGE Open*, *11*(4), 1–16. https://doi.org/10.1177/21582440211054128

Hu, Y., Pan, Y., Yu, M., & Chen, P. (2024). Navigating Digital Transformation and Knowledge Structures: Insights for Small and Medium-Sized Enterprises. *Journal of the Knowledge Economy*. https://doi.org/10.1007/s13132-024-01754-x

Ignatov, A. (2020). The Digital Economy of BRICS: Prospects for Multilateral Cooperation. *International Organisations Research Journal*, *15*(1), 31–62. https://doi.org/10.17323/1996-7845-2020-01-02

Iqbal, B. A., & Yadav, A. (2022). Global value chains in the era of changing globalisation scenario: Perspective from BRICS. *International Journal of Innovation and Sustainable Development*, *1*(1), 1. https://doi.org/10.1504/IJISD.2022.10052067

Islam, M. M. (2022). The Role of Foreign Direct Investment (FDI) Inflows on Export Performance in Developing Economies: Evidence from Bangladesh. *South Asian Journal of Social Studies and Economics*, 49–57. https://doi.org/10.9734/sajsse/2022/v16i3615

Krugman, P. R. (1979). Increasing returns, monopolistic competition, and international trade. *Journal of International Economics*, *9*(4), 469–479. https://doi.org/10.1016/0022-1996(79)90017-5

Lendle, A., Olarreaga, M., Schropp, S., & Vézina, P.-L. (2016). There Goes Gravity: eBay and the Death of Distance. *The Economic Journal*, *126*(591), 406–441. https://doi.org/10.1111/ecoj.12286

Li, J., Pogodin, S., & Vasilyeva, E. (2022). Digitalization Strategy in the BRICS Countries: Towards the Partnership. In A. Beskopylny & M. Shamtsyan (Eds.), *XIV International Scientific Conference INTERAGROMASH 2021*, Vol. 246 (pp. 735–744). Springer International Publishing. https://doi.org/10.1007/978-3-030-81619-3_82

Liu, L., & Nath, H. K. (2013). Information and Communications Technology and Trade in Emerging Market Economies. *Emerging Markets Finance and Trade*, *49*(6), 67–87. https://doi.org/10.2753/REE1540-496X490605

Lucas, R. E. (1988). On the mechanics of economic development. *Journal of Monetary Economics*, *22*(1), 3–42. https://doi.org/10.1016/0304-3932(88)90168-7

Martins, P. S., & Yang, Y. (2009). The impact of exporting on firm productivity: A meta-analysis of the learning-by-exporting hypothesis. *Review of World Economics*, *145*(3), 431–445. https://doi.org/10.1007/s10290-009-0021-6

McFadden, J., Casalini, F., Griffin, T., & Anton, J. (2022). *The digitalisation of agriculture: A literature review and emerging policy issues*. OECD Food, Agriculture and Fisheries Papers, Vol. 176 (p. 57). OECD publishing. https://doi.org/10.1787/285cc27d-en. https://doi.org/10.1787/285cc27d-en

Nath, H. K., & Liu, L. (2017). Information and communications technology (ICT) and services trade. *Information Economics and Policy*, *41*, 81–87. https://doi.org/10.1016/j.infoecopol.2017.06.003

Nayyar, D. (2020). BRICS, emerging markets, and the world economy. In D. Nayyar, *Handbook of BRICS and Emerging Economies* (pp. 93–115). Oxford University Press. https://doi.org/10.1093/oso/9780198827535.003.0003

Nham, N. T. H., Bao, N. K. Q., & Ha, L. T. (2023). Nonlinear effects of digitalization on export activities: An empirical investigation in European countries. *Technological and Economic Development of Economy*, *29*(3), 1041–1079. https://doi.org/10.3846/tede.2023.17061

Oyelami, L. O., Sofoluwe, N. A., & Ajeigbe, O. M. (2022). ICT and agricultural sector performance: Empirical evidence from sub-Saharan Africa. *Future Business Journal*, *8*(1), 18. https://doi.org/10.1186/s43093-022-00130-y

Oyelaran-Oyeyinka, B., & Lal, K. (2005). Internet diffusion in sub-Saharan Africa: A cross-country analysis. *Telecommunications Policy*, *29*(7), 507–527. https://doi.org/10.1016/j.telpol.2005.05.002

Ozcan, B. (2018). Information and communications technology (ICT) and international trade: Evidence from Turkey. *Eurasian Economic Review*, *8*(1), 93–113. https://doi.org/10.1007/s40822-017-0077-x

Palamalai, S. (2016). Causal Nexus between Export and Growth: BRICS Nations. *SCMS Journal of Indian Management*, *8*(1), 67–80. https://papers.ssrn.com/abstract=2763408

Pesaran, M. H., & Shin, Y. (1999). An Autoregressive Distributed-Lag Modelling Approach to Cointegration Analysis. In S. Strom (Ed.), *Econometrics and*

Economic Theory in the 20th Century (pp. 371–413). Cambridge University Press. https://doi.org/10.1017/CCOL521633230.011

Ramakgasha, M. J., Gidi, L. S., & Thaba, T. K. (2023). An analysis of the relationship between exports and economic growth in South Africa, 2000–2020. *Journal of Agribusiness and Rural Development*, *69*(3), 333–340. https://doi.org/10.17306/J.JARD.2023.01709

Rodriguez-Crespo, E., Marco, R., & Billon, M. (2018). ICTs impacts on trade: A comparative dynamic analysis for internet, mobile phones and broadband. *Asia-Pacific Journal of Accounting & Economics*, *28*(5), 577–591. https://doi.org/10.1080/16081625.2018.1519636

Romer, D. (2012). Chapter 3 Endogenous Growth. In *Advanced macroeconomics*, 4th ed. (pp. 101–145). McGraw-Hill/Irwin.

Romer, P. M. (1990). Endogenous Technological Change. *Journal of Political Economy*, *98*(5, Part 2), S71–S102. https://doi.org/10.1086/261725

Saggi, K. (2002). Trade, Foreign Direct Investment, and International Technology Transfer: A Survey. *The World Bank Research Observer*, *17*(2), 191–235. https://doi.org/10.1093/wbro/17.2.191

Tadesse, G., & Badiane, O. (2018). Determinants of African agricultural exports. In *Africa agriculture trade monitor 2018, Eds. Ousmane Badiane, Sunday P. Odjo, and Julia Collins* (pp. 85–109). International Food Policy Research Institute (IFPRI). https://doi.org/10.2499/9780896293496_05.

UNCTADstatistics. (2023). *United Nations Conference on Trade and Development Statistics*. https://unctadstat.unctad.org/datacentre/dataviewer/my-report/3324

Van Der Walt, F., Thasi, M. M. E., Jonck, P., & Chipunza, C. (2016). Skills Shortages and Job Satisfaction-Insights from the Gold-Mining Sector of South Africa. *African Journal of Business and Economic Research (AJBER)*, *11*(1), 141–181.

Wang, M. L., & Choi, C. H. (2018). How information and communication technology affect international trade: A comparative analysis of BRICS countries. *Information Technology for Development*, *25*(3), 455–474. https://doi.org/10.1080/02681102.2018.1493675

World Development Indicators | DataBank. (2024). https://databank.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG/1ff4a498/Popular-Indicators#

Yarygina, I. Z., Zhiglyaeva, A. V., Vershinina, O. V., & Kuvshinova, Yu. A. (2020). Trade and Economic Cooperation of BRICS: Problems and Prospects. Academic *Journal of Interdisciplinary Studies*, *9*(6), 89. https://doi.org/10.36941/ajis-2020-0114

Yin, Z. H., & Choi, C. H. (2024). How does Digitalization Affect Trade in Goods and Services? Evidence from G20 Countries. *Journal of the Knowledge Economy*. https://doi.org/10.1007/s13132-024-02029-1

Zare, J., & Persaud, A. (2024). Digital transformation and business model innovation: A bibliometric analysis of existing research and future perspectives. *Management Review Quarterly*. https://doi.org/10.1007/s11301-024-00426-z

ДА ЛИ ЈЕ ДИГИТАЛИЗАЦИЈА КАТАЛИЗАТОР ИЗВОЗА ЗЕМАЉА БРИКС-А: ЕМПИРИЈСКА АНАЛИЗА

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САЖЕТАК

Дигитализација представља кључни катализатор трансформације међународне трговине кроз унапређење ефикасности, смањење трошкова, проширење приступа тржишту и отварањем нових могућности, чиме се значајно побољшава извозна ефикасност. Разумијевање ове међузависности од суштинског је значаја за земље чланице БРИКС-а – Бразил, Русију, Индију, Кину и Јужноафричку Републику – које имају важну улогу у глобалној трговини. Ово истраживање испитује однос између дигитализације и извоза у оквиру БРИКСА-а, с посебним фокусом на то како информационе и комуникационе технологије (ИКТ) дјелују као катализатор извоза. Коришћењем комбинације панел модела и модела ауторегресивне дистрибуционе заостале структуре (АРДЛ) по земљама, методологија омогућава обухватан увид у хетерогеност међу земљама и у динамику краткорочних и дугорочних ефеката. Панел АРДЛ модел идентификује заједничке трендове у оквиру БРИКС-а, док модели по земљама издвајају специфичне националне ефекте, чиме се додатно оснажује анализа. Резултати показују да у кратком року ефекат ИКТ-а на извоз варира у зависности од коришћеног модела, док у дугом року ИКТ досљедно показује статистички значајан утицај. Налази указују на кључну улогу дигитализације у унапређењу извоза земаља БРИКС-а, нарочито дугорочно. Ипак, степен дјелотворности разликује се међу земљама. Разлике у дигиталној инфраструктури, дигиталној писмености и институционалном квалитету сугеришу да дигитализација сама по себи није довољна. Превазилажење ових изазова омогућило би земљама БРИКС-а да у потпуности искористе потенцијал дигитализације и ојачају своју позицију као значајни извозници у настајању. Ово истраживање доприноси дискурсу о дигиталној економији кроз емпиријски засноване препоруке за обликовање политика.

Кључне ријечи: *дигитализација, извоз, БРИКС, глобална трговина, ИКТ, усвајање технологије, АРДЛ.*

THE INTERACTION BETWEE THE EFFECTIVENESS OF FINANCIAL INSTITUTIONS AND THE FLOW OF FOREIGN INVESTMENT: AN INTEGRATIVE ANALYSIS IN THE ALGERIAN ECONOMY 2000-2023

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ABSTRACT

This study aims to analyse the relationship between the effectiveness of financial institutions and foreign investment flows in light of time-series data. The results showed that the financial institutions effectiveness index remained relatively stable during the studied period, while the foreign investment flow index experienced noticeable fluctuations. Using unit root and cointegration tests, it was found that the two time series, FIEI and DFI, are stationary at level (I(0)) and do not suffer from unit root problems. Furthermore, the results of the bounds test showed the existence of cointegration between the two indices at 1%, 5% and 10% significance levels. Through the standard model, it was found that the FIEI (-1) index has a positive and statistically significant impact on foreign investment flow, while the FDI index did not show a significant effect. The equilibrium correction rate (ECT) was found to be 41.79%, indicating a continuous correction of the gap between actual and balanced values.

1. INTRODUCTION

Amid rapid global economic changes, financial institutions have become the cornerstone of economic market development and driving economic growth. In this context, the effectiveness of these institutions plays a pivotal role in attracting foreign direct investment (FDI), which is one of the most important sources of funding for sustainable economic growth. The interaction between the effectiveness of financial institutions and foreign investment flows represents a

complex mechanism, with the mutual influence of domestic financial policies and global trends.

Since the beginning of the 21st century, Algeria has witnessed significant economic transformations, facing structural challenges that require strategic responses to improve economic efficiency. In this regard, the interaction between the effectiveness of financial institutions and foreign investment flows is of particular importance. This interaction is reflected in the financial system's ability to attract foreign capital, which directly contributes to enhancing and sustaining economic growth.

The role of financial institutions in Algeria, including banks, capital markets and investment funds, is central to achieving financial system stability, which in turn is reflected in foreign investment flows. By analysing this relationship, we can explore how indicators of financial system effectiveness such as transparency, access to finance and capital market development influence the attraction of foreign direct investment.

Research problem:

The relationship between the effectiveness of financial institutions and foreign investment flows is a significant issue in economics. Researchers aim to understand how the effectiveness of these institutions influences investment attraction, particularly amidst economic fluctuations. There is a need for a new analysis that considers both local and global variables to comprehend how the effectiveness indicators interact with investment flows and their impact on economic stability. The study addresses the issue of whether the effectiveness of institutions directly contributes to attracting foreign investment or external factors play a more significant role in determining these flows.

Hypothesis:

The effectiveness of financial institutions positively contributes to attracting foreign direct investment flows, affecting the stability of these flows. Thus there is a common relationship between economic indicators related to financial institutions and investment flow indicators under different economic environments.

This study aims to highlight these dynamics and analyse their impact from 2000 to 2023, with the goal of providing practical insights that contribute to the development of future economic strategies.

2. PREVIOUS STUDIES

1. Study by Ali (2022). This study examines the determinants of foreign direct investment (FDI) inflows in the Kurdistan region, focusing on financial and economic institutional efficiency. The research employs a quantitative approach to analyse how the economic environment and financial structures impact FDI attraction.

Findings:

The study found that FDI inflows are positively influenced by economic activity levels and trade openness. Additionally, enhancing financial institutions' efficiency is a crucial factor in fostering foreign investments.

2. Study by Hassan & Youssef (2021). This study aims to analyse the causal relationship between financial institution development, particularly the banking sector, and FDI inflows in Egypt. It utilises cointegration models and time series analysis to explore the link between these variables.

Findings:

The results indicate a positive long-term relationship between banking sector efficiency and FDI inflows. A strong and stable financial system enhances investor confidence, leading to increased foreign capital inflows.

3. Study by Al-Qahtani (2020). This study examines the impact of FDI on economic growth and integration in the Gulf Cooperation Council (GCC) countries, with a focus on the role of financial institutional efficiency in supporting foreign capital inflows.

Findings:

The study highlights that FDI significantly contributes to economic growth, especially when a stable investment environment and efficient financial institutions are present. It also emphasizes that regulatory factors and economic policies play a critical role in fostering foreign investments.

General conclusion from previous studies

All reviewed studies confirm that the efficiency of financial institutions is a key factor in attracting FDI. When financial institutions are stable and transparent, they boost investor confidence, leading to increased foreign investment inflows. Additionally, the studies underline the importance of integrating economic reforms with financial development to create a sustainable investment climate.

4. Study by Bentafat, Mohamed. (2022). This study highlights that the impact of fiscal policy components on foreign direct investment (FDI) inflows is not uniform. It shows that certain policies, such as increased government spending, may stimulate foreign investments by improving infrastructure and boosting economic activity. Conversely, the findings indicate that high taxation can pose a barrier to FDI inflows by reducing the expected returns for foreign investors. Therefore, the study suggests that balancing fiscal policy between economic stimulation and investor attraction is essential for enhancing FDI inflows.

5. Study by Ben Laamoudi & Akoun (2022). The results of this study indicate that FDI inflows positively contribute to long-term economic growth in Algeria, suggesting that foreign investments help increase productivity and enhance both physical and human capital. However, the study also highlights an insignificant negative impact on unemployment rates, which may imply that foreign investments in Algeria are concentrated in capital-intensive rather than labour-intensive sectors. Additionally, it suggests that there may be challenges related to integrating local labour into foreign enterprises.

6. Study by Nthangu, N. D, and all (2025). The findings of this study reveal that financial stability and transparency in economic policies are among the most significant factors contributing to attracting FDI in North African countries. Countries with clear and stable fiscal policies can provide an attractive investment environment for foreign capital, thereby enhancing FDI inflows. The study also emphasises the importance of reducing bureaucratic barriers and improving banking systems to strengthen foreign investors' confidence.

7. Study by El Sherif, M and all (2024). This study confirms that governance quality plays a crucial role in determining the ability of Arab countries to attract FDI. The findings show that weak institutions, administrative corruption and poor rule of law reduce foreign investors' confidence, hindering FDI inflows. Therefore, improving governance quality and institutional transparency is considered one of the essential reforms needed to enhance the investment climate and stimulate foreign capital inflows.

3. THE ROLE OF FINANCIAL DEVELOPMENT IN ATTRACTING FOREIGN DIRECT INVESTMENT: EVIDENCE FROM ALGERIA

Financial development has been a major focus for policymakers and researchers due to its critical role in bridging theoretical gaps in economics. This topic highlights the importance of financial intermediation, particularly the banking

sector, in fostering investment and production by mobilising savings, managing risks and innovating financial services. Researchers agree that the quality and expansion of financial services into new markets constitute a primary channel linking financial sector development to economic growth. However, to achieve the positive effects of financial development, excessive government intervention must be limited, especially in developing countries. Financial markets are a key component of financial development, as they contribute to risk diversification and provide low-cost information, enhancing the attraction of large investments and supplying funding for major projects, thereby driving economic growth (Larabi & Nassour, 2024, p. 4).

The financial sector facilitates the mobilisation of savings and the allocation of credit across space and time, ensuring the flow of funds from ultimate lenders to ultimate borrowers. This process enhances both the quantity and quality of real investments, leading to economic growth and improved living standards (Beck, 2007, p. 27-49). The effectiveness of financial institutions can be assessed based on their ability to provide financial services efficiently and promote sustainable local investments. Development finance institutions are instrumental in fostering economic growth by enabling access to credit, mitigating financial constraints and promoting investment-friendly environments (Demirgüç-Kunt & Levine, 2022, p. 15). Additionally, they support the transition towards financial inclusion by integrating technological advancements, reducing dependence on external aid and enhancing governance frameworks (World Bank, 2023, pp. 22-24).

Governments promote development and community finance institutions to fund economic projects, prioritising sustainable initiatives over traditional banking operations. These institutions enhance project management efficiency, facilitate financial access and act as intermediaries between public aid and private investments, fostering economic growth (Zhang & Chen, 2022, p. 47).

Foreign direct investment (FDI) involves foreign investors' equity stake in a company within the host country, encompassing equity purchases, reinvested earnings, inter-company loans, management contracts and licensing agreements (James X. Zhan. 2023). This investment type directly channels foreign capital into industrial, financial, construction, agricultural and service sectors, where profitability is the primary motivation (Ahmed, 2013). According to the International Monetary Fund (IMF) and the Organisation for Economic Cooperation and Development (OECD), FDI is defined as an investment that grants foreign residents control over projects within a host country, contributing to both capital flow and technological advancement (World Bank, 2023, p. 14)

Foreign direct investment (FDI) fosters long-term economic relationships, granting foreign investors permanent control over subsidiaries in host countries (Guntrip, E. 2016, p. 9). This investment manifests in several forms, including private investment, which is highly concentrated in primary sectors such as oil and natural resources, where foreign companies capitalise on resource extraction at minimal costs (Jasmina, and all, 2017, p6-11).

Another key form is bilateral investment, involving collaboration between local and foreign capital in economic projects, thereby reducing financial strain on national economies while ensuring profitability for local investors (Global Investment Report, 2022, p. 12). Additionally, multinational corporations (MNCs) account for over 80% of global FDI, dominating technology-intensive industries, as well as sectors such as raw material extraction, agriculture, banking, insurance, tourism and manufacturing (World Bank, 2023, p. 33).

Algeria possesses competitive factors that make it an attractive destination for investments, particularly through its legislative, regulatory, and administrative framework, as well as Investment Law No. 22-18 issued on July 24, 2022. Between 2010 and 2023, Algeria experienced significant fluctuations in FDI inflows, reflecting the deep challenges faced by the national economy due to internal and external economic (Table 1).

Table 1. Foreign Direct Investment (FDI) Flows to Algeria from 2010 to 2023

Unit: Million USD.

Years	2010	2011	2012	2013	2014	2015	2016
Inbound Investments	2301	2581	1499	1697	1507	-585	1636
Outbound Investments	220	534	-41	-268	-18	103	47
Years	2017	2018	2019	2020	2021	2022	2023
Inbound Investments	1232	1475	1382	1140	870	255	1216
Outbound Investments	-18	854	31	15	-52	85	84

Source: United Nations Conference on Trade and Development (UNCTAD) Database, 2025.

At the beginning of the past decade, Algeria recorded strong investment inflows, peaking in 2011 at $2,581 million, reflecting a relatively stable economic environment supported by rising oil revenues and investor interest, especially in the energy sector. However, from 2012 onwards, investment inflows have gradually declined due to increasing structural challenges in the Algerian economy, such as excessive dependence on oil and gas, lack of economic diversification, bureaucratic hurdles and an inflexible legal framework, such as the 51/49% rule that restricted foreign investors' rights, leading to a drop in investments to $1,507 million in 2014.

The year 2015 was one of the most challenging periods, as Algeria recorded negative investment inflows of -$585 million, resulting from the global oil price collapse and the increased outflow of foreign capital due to the country's weak business environment. Despite attempts at recovery in subsequent years, Algeria could not return to pre-crisis levels, with investments ranging between $1,232 million in 2017 and $1,382 million in 2019. The crisis worsened in 2020 due to the COVID-19 pandemic, with investments falling to $1,140 million and continuing to decline, reaching their lowest level in 2022 at $255 million. However, 2023 saw a slight improvement, with investments rising to $1,216 million, reflecting some recovery driven by relative political stability and government efforts to encourage investment.

As for Algeria's outbound investments, they have remained modest and inconsistent over the same period, reflecting the limited international expansion of the Algerian private sector. At the beginning of the decade, Algeria recorded positive outbound investment flows, peaking at $534 million in 2011. However, these investments soon became volatile, with negative values in some years, such as -$41 million in 2012 and -$268 million in 2013, indicating the withdrawal of some Algerian companies from foreign markets due to a lack of experience or financial pressures.

The year 2018 was an exception, with outbound investments rising to $854 million, reflecting a rare move toward foreign expansion, possibly due to limited investment initiatives in the energy or trade sectors. However, this trend did not continue, with outbound investments returning to modest or negative levels in later years, such as -$52 million in 2020, highlighting the significant decline in the global competitiveness of Algerian companies.

Throughout this period, Algeria exhibited an imbalance between inbound and outbound flows, relying heavily on foreign investments to finance its development projects while showing weak capacity for Algerian companies to enter international markets. Economic crises, particularly oil price declines, negatively affected both flows simultaneously. Despite efforts to diversify the economy, there were no tangible results in expanding inbound investments to new sectors such as agriculture, tourism or technology, which also impacted outbound investments.

4. EVALUATING THE INFLUENCE OF FINANCIAL INSTITUTIONS' EFFICIENCY ON FDI INFLOWS: AN ECONOMETRIC APPROACH

Our analysis of the role of the Financial Institutions Efficiency Index in attracting Foreign Direct Investment (FDI) in Algeria during the period 2000–2023 highlights the critical importance of this topic within the Algerian economic context. This significance is evident in the multiple challenges facing the national economy, including the need to diversify income sources to reduce excessive reliance on oil revenues, enhance the role of the private sector and attract foreign investments that can contribute to sustainable development. From this perspective, assessing the relationship between the efficiency of financial institutions and their ability to improve the investment climate constitutes a necessary step in understanding the drivers and obstacles to this process.

In this study, we employed the Autoregressive Distributed Lag (ARDL) model due to its capability to analyse short- and long-term relationships between economic variables. The Financial Institutions Efficiency Index (FIEI) was selected as the independent variable, as it reflects the level of efficiency and transparency in the financial and administrative performance of financial institutions, including banks, insurance companies and financial markets. Meanwhile, the FDI inflow index was adopted as the dependent variable, as it represents the attractiveness of the national economy to foreign investors and the extent to which foreign capital is attracted.

A descriptive analysis of the time series for the FIEI and FDI inflow index reveals notable variations in trends over the study period. The FIEI recorded an average of 0.6971, indicating a relatively stable performance over the years. This stability is reinforced by a low variance (0.00055) and a limited standard deviation (0.0235), suggesting minimal fluctuations around the mean. The index values ranged between 0.64 in 2005 and 0.73 during the period 2018–2023, reflecting relative sustainability in the performance of financial institutions (Table 2).

In contrast, the FDI inflow index exhibited greater variability, with an average of 0.7133, slightly higher than that of the FIEI, but with a larger standard deviation (0.5090), indicating significant fluctuations in FDI inflows. The values ranged from a minimum of 0.0157 in 2001 to a maximum of 1.8274 in 2009, with a considerable difference of 1.8118, reflecting varying periods of foreign investment inflows influenced by external factors such as global and local economic policy changes.

Table 2. Descriptive Analysis of Financial Institutions' Efficiency Index and Foreign Investment Flow Index during the Studied Period

Years	2000	2001	2002	2003	2004	2005
Financial Institutions Efficiency Index	0,72	0,68	0,68	0,7	0,65	0,64
Foreign Investment Flow Index	0,02500438	0,01565303	0,16023447	0,03854077	0,26704383	1,07990333
Years	2006	2007	2008	2009	2010	2011
Financial Institutions Efficiency Index	0,67	0,68	0,73	0,7	0,7	0,7
Foreign Investment Flow Index	1,49572335	1,18381815	1,46277345	1,82742165	1,29390467	1,17767329
Years	2012	2013	2014	2015	2016	2017
Financial Institutions Efficiency Index	0,7	0,69	0,7	0,69	0,69	0,7
Foreign Investment Flow Index	0,66055195	0,73655907	0,62868897	0,28683229	0,90630071	0,6479027
Years	2018	2019	2020	2021	2022	2023
Financial Institutions Efficiency Index	0,72	0,7	0,7	0,73	0,73	0,73
Foreign Investment Flow Index	0,75357609	0,71394731	0,69381601	0,46672848	0,10637075	0,49097261

Source: United Nations Conference on Trade and Development (UNCTAD) Database, 2025.

This variation suggests that the FIEI may be more stable compared to the FDI inflow index, highlighting the financial system's ability to maintain relatively balanced performance. Meanwhile, fluctuations in FDI inflows may result from different influences, including economic reforms, regulatory measures, international market conditions and local political and security factors. Therefore, studying the relationship between these two indices can provide a deeper understanding of how financial stability affects foreign capital attraction (Figure 1).

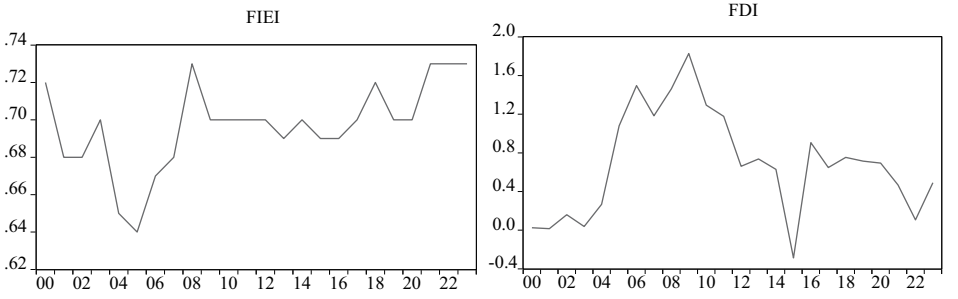

Figure 1. Stability
Source: Prepared by the researchers using EViews software.

To determine the causal relationship between the variables, we first conducted stationarity tests using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) methods. These tests aim to verify whether the time series contains a unit root, a prerequisite before applying the cointegration model. The results indicated that the FIEI and FDI inflow series are stationary at level I(0), meaning that the ARDL model can be used without the need for additional differencing of the data (Table 3).

Table 3. Testing the Stability of Time Series for the Variables under Study

Variables		Augmented Dickey-Fuller (ADF)			Phillips-Perron (PP)		
		Without Constant	Constant and Trend	Constant	Without Constant	Constant and Trend	Constant
FIEI	Computed	-1.956406	-3.622033	-2.998064	-1.956406	-3.622033	-2.998064
	Critical	0.022674	-3.894989	-2.400542	0.117488	-6.894145	-2.400542
DFI	Computed	-1.956406	-3.622033	-2.998064	-1.956406	-3.622033	-2.998064
	Critical	-1.142314	-2.237275	-2.284540	-1.026948	-2.154426	-2.284540

Source: Prepared by the researchers using EViews software.

After confirming the stationarity of the variables, we proceeded to estimate the model using the ARDL approach, which allows for examining the relationship between variables in both the short and long run. To ensure accurate estimation, we determined the optimal lag length using the Akaike Information Criterion (AIC) and Schwarz Criterion (SC). The results showed that the most efficient model relies on a one-period lag (Lag 1), ensuring a balance between model quality and statistical complexity (Table 4).

Table 4. Determining the Lag Order of the Model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	32.95568	NA	0.000132	-3.258493	-3.159078	-3.241668
1	42.72449	16.45273*	7.22e-05*	-3.865736*	-3.567492*	-3.815261*
2	43.65739	1.374791	0.000102	-3.542883	-3.045810	-3.458758
3	45.60499	2.460138	0.000132	-3.326842	-2.630939	-3.209067
4	51.45913	6.162251	0.000119	-3.522014	-2.627282	-3.370590
5	53.22154	1.484134	0.000178	-3.286478	-2.192917	-3.101404

Source: Prepared by the researchers using EViews software.

Next, we conducted the Bounds Test to verify the presence of a long-run equilibrium relationship between the variables. The results showed that the computed F-statistic (6.016628) exceeded the upper bound of critical values at the 1%, 5%, and 10% significance levels, confirming the existence of cointegration

between the variables. Consequently, it can be concluded that there is a long-term relationship linking financial institutions' efficiency to FDI attraction in Algeria (Table 5).

Table 5. Bounds Test for Cointegration

Calculated Fvalue	Critical Values	Significance Level		
		1%	5%	10%
6.016628	Lower Bound I(0)	4.94	3.62	3.02
	Upper Bound I(1)	5.58	4.16	3.51

Source: Prepared by the researchers using EViews software.

Regarding long-term model estimation, the results indicated that the coefficient of FIEI(-1) was 0.582079, statistically significant at the 1% level (p-value = 0.0086), suggesting that financial institutions' efficiency has a strong and positive impact on FDI inflows. In contrast, the FDI coefficient was not statistically significant, reflecting a weak direct causal relationship between past and present FDI inflows (Table 6).

Table 6. Long-Run Model Estimation: Cointegration Regression Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
FIEI(-1)	0.582079	0.199844	2.912668	0.0086
FDI	0.005631	0.008560	0.657829	0.5181
C	0.287118	0.140923	2.037411	0.0551

Source: Prepared by the researchers using EViews software.

For short-term estimation, the Error Correction Model (ECM) was used to analyse the speed of adjustment toward long-term equilibrium. The error correction term was -0.417921, statistically significant at the 5% level (p-value = 0.0179), indicating that approximately 41.79% of short-term imbalances are corrected in each period, reinforcing the cointegration hypothesis between the variables (Table 7).

Table 7. Short-Run Model Estimation and Error Correction Term

ECM Regression				
Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
CointEq(-1)*	-0.417921	0.162004	-2.579704	0.0179

Source: Prepared by the researchers using EViews software

To ensure the reliability and robustness of the model, we conducted several diagnostic tests, including the Autoregressive Conditional Heteroskedasticity (ARCH) test, which confirmed the absence of heteroscedasticity as the probability values were above 5%. The Breusch-Godfrey LM Test for serial correlation showed no autocorrelation in the residuals, enhancing the model's reliability (Table 8 and Table 9).

Table 8. Heteroscedasticity Test (Error Term Stability Test)

Heteroskedasticity Test: ARCH			
F-statistic	0.461635	Prob. F(1,20)	0.5046
Obs*R-squared	0.496342	Prob. Chi-Square(1)	0.4811

Source: Prepared by the researchers using EViews software.

Table 9. Error Independence Test (Autocorrelation of Errors Test)

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.066185	Prob. F(2,18)	0.9362
Obs*R-squared	0.167903	Prob. Chi-Square(2)	0.9195

Source: Prepared by the researchers using EViews software.

However, the Ramsey RESET test indicated potential specification issues, as the probability values were below 5%, suggesting that the model may require structural improvements or the inclusion of additional variables. Nonetheless, the structural stability tests using CUSUM and CUSUM of Squares confirmed that the model is stable, as the values remained within the critical boundaries at the 5% significance level (Table 10 and Figure 2).

Table 10. Ramsey RESET Test

Ramsey RESET Test			
Equation: UNTITLED			
Specification: FIEI FDI			
Omitted Variables: Squares of fitted values			
	Value	df	Probability
t-statistic	2.408529	22	0.0248
F-statistic	5.801013	(1, 22)	0.0248
Likelihood ratio	5.616720	1	0.0178

Source: Prepared by the researchers using EViews software.

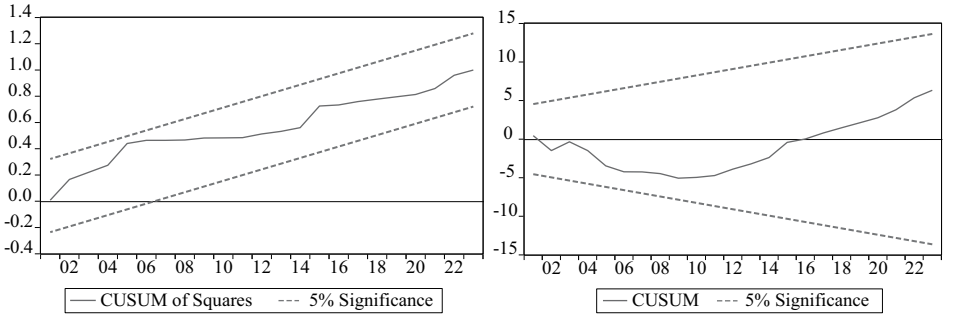

Figure 2. Cumulative Sum of Recursive Residuals (CUSUM) and Cumulative Sum of Squared Recursive Residuals (CUSUM of Squares) Tests
Source: Prepared by the researchers using EViews software.

Finally, the Jarque-Bera test revealed that the residuals follow a normal distribution, confirming the validity of the statistical assumptions used in the model. Based on all these tests, we can conclude that the ARDL model used exhibits a high level of accuracy and reliability, allowing us to draw meaningful conclusions about the relationship between financial institutions' efficiency and FDI inflows in Algeria (Figure 3).

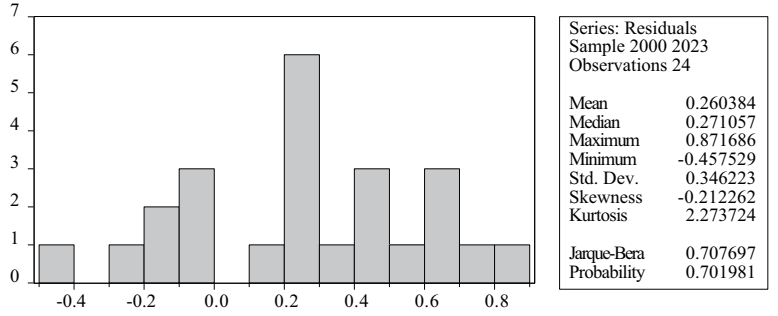

Figure 3. Normality Test of Residuals
Source: Prepared by the researchers using EViews software.

5. DISCUSSIONS

The empirical findings of this study provide valuable insights into the relationship between financial institutions' effectiveness and foreign direct investment (FDI) inflows in Algeria. The Financial Institutions Effectiveness Index (FIEI) demonstrated relative stability throughout the study period (2000–2023), suggesting that Algeria's financial institutions maintained a moderate degree of efficiency. This aligns with previous studies (e.g., Ali, 2022; Hassan & Youssef, 2021), which found that financial sector stability fosters investor confidence.

However, despite this stability, FDI inflows exhibited significant volatility, underscoring the role of external economic, political and policy-related factors in shaping investment dynamics.

The unit root tests confirmed that both FIEI and FDI time series were stationary at level (I(0)), supporting the robustness of the subsequent cointegration analysis. The Bounds Test revealed a significant long-run relationship between financial institutions' effectiveness and FDI, reinforcing the idea that institutional quality serves as a key determinant of foreign investment attraction. This finding is consistent with Al-Qahtani (2020), who highlighted that strong financial institutions contribute to sustained economic integration and investment flows in GCC countries. Additionally, El-Hadi (2020) found that fiscal policies play a crucial role in attracting FDI in North African countries, suggesting that institutional effectiveness must be complemented by sound macroeconomic policies. Similarly, Ben Issa (2023) demonstrated that fiscal policy components significantly impact FDI inflows in Algeria, further highlighting the interplay between institutional and economic factors.

Long-run implications

The estimated long-run model revealed that the lagged FIEI (-1) had a statistically significant positive effect on FDI inflows, confirming that improvements in institutional effectiveness enhance Algeria's attractiveness to foreign investors. This result aligns with the findings of Hassan and Youssef (2021), who emphasised the crucial role of banking sector efficiency in FDI mobilisation. However, the FDI variable itself did not exhibit statistical significance, indicating that foreign investment inflows may be influenced by additional macroeconomic and political variables beyond institutional efficiency alone. This suggests that, while a strong financial system is a necessary condition for investment attraction, it is not solely sufficient. Factors such as government policies, trade openness and economic stability must also be considered to create a comprehensive investment-friendly environment. Furthermore, Ben Laamoudi and Akoun (2022) employed an ARDL model to analyse the impact of FDI on economic growth in Algeria, emphasising that foreign investment contributes positively to development only when coupled with effective institutional frameworks.

Short-Run Adjustments and Market Dynamics

The Error Correction Term (ECT) of -0.4179 suggests that approximately 41.79% of deviations from long-run equilibrium are corrected each period. This implies that, despite fluctuations, the Algerian economy demonstrates a moderate ability to adjust and stabilize over time. Such findings are crucial for policymakers,

as they indicate that structural reforms aimed at financial institutions will yield positive investment effects, albeit with some delay.

Moreover, the model validation tests confirmed the reliability of the results. The heteroskedasticity test ruled out variance instability issues, ensuring that the estimated relationships remain statistically sound. However, it is important to note that exogenous factors such as global economic crises, political instability and sudden regulatory changes may still exert substantial short-term influence on investment decisions. This aligns with El-Sherif (2021) who found that governance plays a fundamental role in shaping FDI patterns in Arab countries, reinforcing the need for stronger institutional governance in Algeria.

Policy Recommendations and Future Considerations

1. Strengthening Financial Institutions – Given the significant long-run relationship between FIEI and FDI, Algeria should focus on enhancing financial transparency, regulatory efficiency and banking sector resilience to sustain investor confidence.

2. Diversifying Investment Incentives – While institutional effectiveness is essential, complementary measures such as fiscal incentives, trade openness and economic diversification must be pursued to further attract FDI.

3. Macroeconomic Stability and Governance – Addressing external risks, such as policy uncertainty and global economic fluctuations, will be crucial in mitigating the volatility observed in FDI flows.

6. CONCLUSIONS

The study findings confirm that financial institutions' effectiveness plays a fundamental role in Algeria's FDI attractiveness, however, investment inflows are also highly sensitive to external economic and policy-driven factors. These results reinforce the importance of institutional reforms, financial stability and macroeconomic strategies in fostering a sustainable investment climate. Future research should explore additional variables, such as political stability, trade policies and sectoral FDI composition, to provide a more comprehensive understanding of the determinants of foreign investment in Algeria.

Recommendations

- Enhancing financial institutions' efficiency: improving transparency, governance and leveraging innovative financial technologies to increase foreign investors' confidence.

- Diversifying the economy: reducing dependence on traditional sectors such as oil and investing in productive industries like manufacturing, agriculture and technology.
- Improving the investment environment: eliminating bureaucratic obstacles and strengthening political and social stability to make the investment climate more attractive.
- Encouraging international partnerships: establishing strategic partnerships with multinational corporations to bring expertise and advanced technology.
- Developing human resources: implementing advanced training programs to equip the local workforce with skills aligned with investors' needs in targeted sectors.

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Conflict of interest

The authors declare there is no conflict of interest.

REFERENCES

Ahmed, S. (2013). Foreign Direct Investment, Trade and Economic Growth: Challenges and Opportunities. Routledge India. https://doi.org/10.4324/9781315816203

Al-Qahtani, K. (2020). Foreign Direct Investment and Its Impact on Economic Growth and Integration in the Cooperation Council of the Arab Gulf States. *Journal of Economic Studies, 28*(3), 112-129. https://www.kau.edu.sa/Files/320/Researches/66728_38265.pdf

Algeria Investment Promotion Agency. (2024). *Investment promotion in Algeria*. Investissement étranger en Algérie-EN – AAPI

Ali, M. (2022). The Determinants of the Flow of Foreign Direct Investment: A Case Study of the Kurdistan Region. *Humanities Journal of University of Zakho, 10*(2), 25-40. https://hjuoz.uoz.edu.krd/index.php/hum/article/view/1072/802

Beck, T, and all. (2007). *Finance, Inequality and the Poor*. Journal of Economic Growth, 12(1), 27–49. https://link.springer.com/article/10.1007/s10887-007-9010-6

Bentafat, Mohamed. (2022). The Impact of Fiscal Policy Components on Foreign Direct Investment in Algeria (2000-2020). Advanced research in economics and business strategy journal, *03*(2), 45-63. https://asjp.cerist.dz/en/downArticle/757/3/2/210819

Ben Laamoudi, A. & Akoun, M. (2022). The Impact of Foreign Direct Investment on Economic Growth in Algeria Using the ARDL Model (1991-2021). https://dspace.univ-ouargla.dz/jspui/handle/123456789/34957

Demirgüç-Kunt, A., & Levine, R. (2022). *Finance, Growth, and Inequality: The Role of Financial Institutions*. MIT Press. https://doi.org/10.5089/9781513583365.001

EcoTimes DZ. (2024). *Investissement: Comment l'Algérie compte attirer les IDE?* https://ecotimesdz.com/investissement-comment-lalgerie-compte-attirer-les-ide/

Nthangu, N. D, and all (2025). *The Impact of Fiscal Policy on Foreign Capital Inflows in Selected Sub-Saharan African Countries*. International Journal of Economics and Financial Issues, 15(3). https://doi.org/10.32479/ijefi.18377

El Sherif, M and all (2024). *An Examination of Impact of Regulation Efficiency on Foreign Direct Investment: The Role of Institutional Quality in MENA Region from (2000–2020)*. Open Journal of Social Sciences, 12(8). https://doi.org/10.4236/jss.2024.128024

Global Investment Report. (2022). *Trends in Bilateral and Multinational Investments.* UNCTAD Publications. https://unctad.org/system/files/official-document/wir2022_en.pdf

Hassan, A., & Youssef, M. (2021). The Causal Relationship between Foreign Direct Investment Flows and Financial Development in the Banking Sector: An Applied Study on Egypt. *Contemporary Financial & Digital Journal, 15*(1), 89-104. https://cfdj.journals.ekb.eg/article_133038_1a87acc5d66a4ca5d99b4b9ad3a05e8c.pdf

Jasmina, and all. (2017). *Foreign Direct Investment, Finance, and Economic Development*. Harvard Business School. https://www.hbs.edu/ris/Publication%20Files/FDICapital_Formatted_20170922_Final_W_c7fcb82c-f318-4632-a589-20118eaeebf8.pdf

James X. Zhan. (2023). *Global Investment Trends and Policies at Times of Uncertainty*. In *Investment Claims* (Yearbook articles). Oxford University Press. https://oxia.ouplaw.com/abstract/10.1093/law-iic/9780198853343.016.0001/law-iic-9780198853343-document-1

Larabi, A., & Nassour, A. (2024). Financial sector in Algeria: Analysing some facts and challenges. *Finance & Markets Review, 8*(2), 4. https://asjp.cerist.dz/en/downArticle/329/8/3/163293

Guntrip, E. (2016). *Self-Determination and Foreign Direct Investment: Reimagining Sovereignty in International Investment Law*. International & Comparative Law Quarterly, 65(4), 829–857. https://doi.org/10.1017/S0020589316000324

United Nations Conference on Trade and Development. (2024). *World Investment Report 2024*. https://unctad.org/publication/world-investment-report-2024

World Bank. (2023). *FDI, Development, and Economic Integration: Policies for Sustainable Growth*. World Bank Publications, Washington, DC, , https://openknowledge.worldbank.org/

World Bank. (2023). *Financial Inclusion and Sustainable Development: Global Trends and Policies*. World Bank Publications, Washington, DC. https://www.albankaldawli.org/ar/topic/financialinclusion/overview

World Bank Algeria. (2024). *Country overview*. https://www.albankaldawli.org/ar/country/algeria/overview

Zhang, Y., & Chen, L. (2022). *Financial Institutions and Economic Development in the 21st Century*. Routledge. https://doi.org/10.4324/9781315704326

ИНТЕРАКЦИЈА ИЗМЕЂУ ЕФИКАСНОСТИ ФИНАНСИЈСКИХ ИНСТИТУЦИЈА И ТОКА СТРАНИХ УЛАГАЊА: ИНТЕГРАТИВНА АНАЛИЗА У АЛЖИРСКОЈ ЕКОНОМИЈИ 2000–2023.

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САЖЕТАК

Ова студија има за циљ да анализира однос између ефикасности финансијских институција и токова страних улагања на основу временских серија података. Резултати су показали да је индекс ефикасности финансијских институција остао релативно стабилан током проучаваног периода, док је индекс тока страних улагања биљежио примјетне флуктуације. Користећи тестове за јединични коријен и коинтеграцију, утврђено је да су двије временске серије, FIEI и DFI, стационарне на нивоу (I(0)) и да немају проблем са јединичним коријеном. Даље, резултати теста граничних вриједности показали су постојање коинтеграције између ова два индекса на нивоима значајности од 1%, 5% и 10%. Кроз стандардни модел, утврђено је да индекс FIEI (-1) има позитиван и статистички значајан утицај на ток страних улагања, док индекс FDI није показао значајан ефекат. Стопа корекције равнотеже (ECT) износила је 41,79%, што указује на континуирану корекцију разлике између стварних и уравнотежених вриједности.

Кључне ријечи: *ефикасност финансијских институција, страна директна улагања (СДУ), коинтеграција, АРДЛ модел, инвестиционо окружење.*

PUBLIC MEETS PRIVATE: UNRAVELING THE DYNAMICS OF INFRASTRUCTURE INVESTMENT IN SOUTH AFRICA

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ABSTRACT

Private investment plays a pivotal role in job creation and economic growth. Given its importance, this study scrutinised the dynamics of how public investment, particularly in critical infrastructures, either complements or competes with private investment. The study delved into the intricate relationship between private investment and government-led investment in critical infrastructure in health and electricity generation in South Africa. Quarterly time series data from 2006Q2 to 2023Q2 were used while adopting the autoregressive distributed lag (ARDL) technique. According to the econometric analysis, government spending in health and electricity generation complements private investment. The effects of the investment in the critical infrastructure variables on the ratio of private investment to GDP are quite low, although highly statistically significant. The findings underscore the importance of well-targeted infrastructure investments in driving private-sector development. Overall, this comprehensive analysis contributes to understanding the complex dynamics between public and private investments in the context of critical infrastructure development in South Africa. The findings of this study are essential for policymakers, investors and researchers seeking to enhance the effectiveness of economic policies and foster sustainable economic development in the country.

1. INTRODUCTION

The economic development of a country hinges significantly on domestic and, more specifically, private investment. Private investment, influenced by a myriad of factors, including infrastructure and infrastructure investment (Molapo and Damane, 2015; Batu, 2016), plays a pivotal role in job creation and economic growth. It is important to note the difference in these terms within the

broader context of economic development. "Infrastructure" encompasses vital physical structures necessary for a country's operation, such as transportation, water, power, energy and telecommunication infrastructures. On the other hand, "infrastructure investment" involves the allocation of financial resources for the planning and maintenance of these structures. Such investment is a crucial step towards building a robust economy and is a key determinant of economic performance.

While various entities, including governments, private enterprises and international organisations, contribute to funding infrastructure investments (Global Infrastructure Hub, 2023), this study focused on government-led infrastructure investment in South Africa. The impact of such investment on economic development is substantial, not only generating jobs during the construction phase but also laying the groundwork for sustained economic growth. Well-planned infrastructure investments can attract additional investments, stimulate economic activity and enhance a country's overall competitiveness. In addition to different examples of public infrastructure, there are also different types of infrastructure, such as soft infrastructure, hard infrastructure and critical infrastructure. Soft infrastructure includes education, law and order; hard infrastructure includes transport and communication services, while critical infrastructure is regarded as being crucial to the functioning of an economy and includes energy, public health and drinking water.

Therefore, we ask the question, why the focus on private investment? The private sector's contribution to total gross fixed capital formation in South Africa, as depicted in Figure 1, underscores its pivotal role in the country's economy. It is thus imperative to scrutinise how public investment in critical infrastructure influences growth in this sector's investment. This study aimed to investigate the impact of investment in critical infrastructures that would be economically significant determinants of private investments – specifically, total expenditures on health and available electricity – on private investment in South Africa. It is believed that for an economy to benefit from long-term capital flows, conditions such as sufficient infrastructure and human capital, among others, are required (Bengoa and Sanchez-Robles, 2003; Ahmed et al., 2018). Investment in water and sanitation does not have a clear supporting logical influence on private investments.

Furthermore, South Africa's labour market is characterised by diverse working hours and varying levels of labour productivity across different sectors and genders, where men typically work an average of four hours longer per week than women, according to the Statistics South Africa Labour Market Dynamic report

(Statistics South Africa, 2022). South Africa's Basic Conditions of Employment Act provides for a minimum of 30 days of paid sick leave over a three-year cycle. Meanwhile, frequent or extended sick leave can negatively affect labour productivity by reducing the available workforce or by increasing the workload on remaining employees. Investing in healthcare in the long term can help to decrease the number of registered sick days and increase labour productivity. South Africa has therefore embarked on several successful health infrastructure projects, including the recent National Health Insurance Bill that the National Assembly passed in May 2024, which is intended to improve healthcare service delivery and socioeconomic development.

Among the many factors that determine private investment, a major influential variable is public investment, in this case, the investment in infrastructure (Bengoa and Sanchez-Robles, 2003; Adugna, 2013; Hailu and Debele, 2015). In examining the relationship between public and private investments, the complexity of their interaction is acknowledged. Public investment, particularly in infrastructure, can either crowd in or crowd out private investment, depending on the specific dynamics. Crowd-in private investment occurs when public investment positively affects private investment, and crowd-out private investment occurs when public investment adversely affects private investment (Eduardo and Christian, 2011; Nyoni and Bonga, 2017).

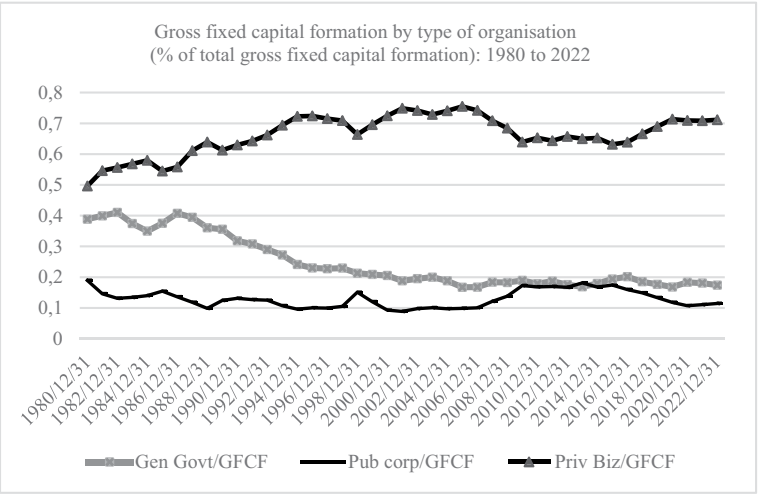

Figure 1: Share of general government, public corporation and private business investments as a percentage of total gross fixed capital formation
Source: Author's compilation from SARB Quarterly Bulletin, 2023

Furthermore, the establishment of the Infrastructure South Africa (ISA) programme in May 2022 underscores the country's commitment to accelerate infrastructure investment projects. This initiative aligns with the National Infrastructure Plan 2050 (NIP 2050), emphasising the public sector's role in driving economic development through increased employment (Government Gazette, 2022). Infrastructure plays a crucial role in shaping the investment landscape of South Africa by directly influencing private investment patterns.

However, it is important to highlight South Africa's legal and regulatory barriers to public-private infrastructure investment. The environment for infrastructure investment is governed by multiple overlapping statutes, which lead to many challenges, such as complex and fragmented regulations, cumbersome approvals, procurement bottlenecks and uncertainty in the legal procedures. For instance, the public-private partnership regulations (2004, updated 2017) under the National Treasury provide the framework for procedures, procurement, contracting, monitoring and compliance concerning all projects carried out. These sometimes lead to delays as a result of the multiple layers of approval, lack of harmonisation and procurement requirements, which are inconsistent, thereby frustrating and discouraging private investors.

Furthermore, in many instances, the approval processes are slow, which can take years. There are constraints in the regulations of some sectors, for instance, the delay in the energy sector, whereby the regulatory delays by the National Energy Regulator of South Africa (NERSA) have slowed the Independent Power Producer (IPP) approvals. In general, these legal and regulatory issues lead to increased transaction costs and extension of the project timeframes, among others, thereby dampening the private investment and limiting the effectiveness of the government spending in crowding in private investment.

Figure 2 illustrates the trend in private investment as a percentage of gross domestic product (GDP) from 1980 to 2022. Private investment declined by about 6 per cent during the same period, with the highest increase of over 18 per cent reported in December 1981. There was also an uptick in December 2008, after the onset of the global financial crisis, and just before it ended in June 2009 (The Wall Street Journal, 2008). Recognising the decline in private investment over certain periods, especially after the global financial crisis of 2008, where it did not increase beyond 16 per cent, prompted an investigation into the factors influencing this movement.

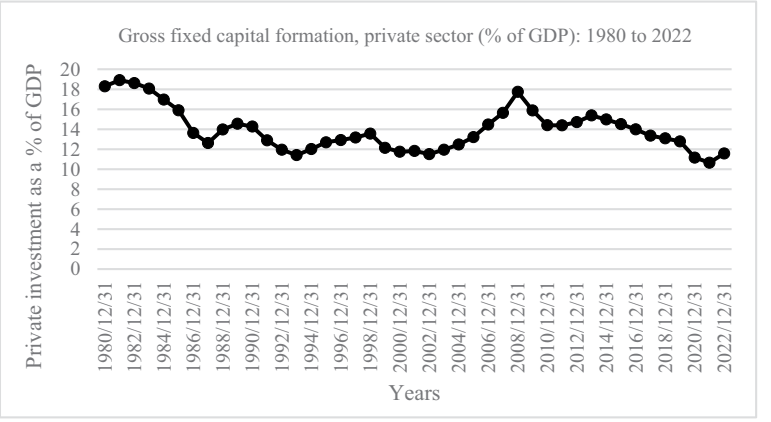

Figure 2: Trend in private investment (as a percentage of gross domestic product)
Source: Author's compilation from SARB Quarterly Bulletin, 2023

Some of the factors contributing to the movement in private investment could be attributed to government spending. The study thus identified two major critical infrastructure investments – healthcare and electricity generation – as focal points for analysis. The study aimed to answer the following three questions: 1) Does government investment in each of these critical infrastructures complement or compete with private investment in South Africa? In other words, is government spending crowding in promoting the expansion and development of the private sector, or is it crowding out private investment in South Africa? 2) To what extent do changes in interest rates influence the percentage of private investment to GDP? Lastly, 3) Does the acceleration theory hold for South Africa?

2. LITERATURE REVIEW

Drawing on economic theories related to infrastructure investment and private investment, this section of the paper will first provide a theoretical foundation for understanding the interconnectedness of infrastructure investment and private investment. This will be followed by a review of existing literature highlighting empirical evidence of the link between critical infrastructure investment and private investment.

The availability of infrastructure creates a conducive environment for investment flow. Also, based on existing literature, domestic investment plays a crucial role in a nation's economic growth by helping to develop the economy through capital formation (Yousaf and Naila, 2018). According to Wai and Wong (1982), a large component of government investment is concentrated on infrastructure

projects in most developing countries. This is because the creation of special infrastructure facilities by the government for transport, health, electric power, irrigation, etc. will reduce the cost of production or increase the returns to scale, thereby increasing the profitability for private investors.

According to the Keynesian and neoclassical schools of thought, the former assume that there is crowding in of private investment in the economy, while the latter believe that government spending will crowd out private investment. The Keynesians suggest that given an expansionary fiscal policy, whereby the government increases its spending and introduces a tax cut, the country's output level will increase. Thus, Keynesian theorists assert that an expansionary fiscal policy will cause an increase in the private sector through the multiplier effect (Şen and Kaya, 2014; Omojolaibi, Okenesi & Mesagan, 2016).

Meanwhile, the neoclassical theorists suggest that given an expansionary fiscal policy, the government will borrow to finance its spending. This will lead to an increase in interest rates, thus resulting in less funds available for private-sector consumption and investment, which means that government spending will crowd out private investment (Sineviciene & Vasiliauskaite, 2012). Contrary to both the neoclassical and the Keynesian approaches, the Ricardian Equivalence hypothesis assumes that there is no relationship between private investment and government spending. The proponents of this theory argue that the revenue from tax funds most of the government spending, and when there is a budget deficit, individuals and the private sector will continue to maintain their levels of consumption and investment behaviours in the economy (Omitogun, 2018).

Other theoretical foundations include the theories on sustainable finance, public-private partnerships (PPPs) and economic models of public investment, which are discussed briefly. While the PPPs are long-term cooperative arrangements between the public and private sectors in delivering infrastructure or services and offering a mechanism to leverage private capital and expertise in order to achieve public goals, the economic models of public investment include the endogenous growth theory by Barro (1990) among others. Barro (1990) argued that public investment in infrastructure can enhance private sector productivity by improving the marginal efficiency of capital, leading to crowding in private investment.

On the empirical front, Perkins, Fedderke and Luiz (2005) carried out a study in South Africa to observe the long-term trend of the following economic infrastructure, namely railways, roads, ports, air travel, telephone lines and electricity on economic growth, using the Pesaran, Shin and Smith (2001) F-test approach to determine the direction of the association. They found that economic

infrastructure is important for promoting adequate economic growth. The study emphasised the importance of the maintenance and expansion of infrastructure to support economic activity in a growing economy. However, the study by Maluleke, Odhiambo & Nyasha (2023) investigated the linear and non-linear impact of public investment on private investment in South Africa using annual data spanning the period from 1980 to 2018. The study used autoregressive distributed lag (ARDL) and non-linear autoregressive distributed lag (NARDL) techniques. While the public investment was not disaggregated over different infrastructure and non-infrastructure spending, the study used per capita GDP to proxy economic growth. Maluleke, Odhiambo & Nyasha (2023) found that public investment has an asymmetric effect on private investment in South Africa, with negative shocks leading to a decrease and positive shocks resulting in an increase in private investment in both the short and long run.

Ahmed et al. (2018) analysed the critical importance of energy infrastructure for domestic investments in Nigeria, using annual data spanning from 1980 to 2016, and adopting the autoregressive distributed lag (ARDL) technique. The study found that although public investment crowds in private investment, this is statistically insignificant. Thus, there is a positive but insignificant effect of energy infrastructure on domestic investment. The study suggested that the result is due to the non-professional execution of government spending on energy infrastructure through the diversion of funds to private purses. However, another possible reason could be the proxy used for the energy infrastructure, namely the electricity consumption rate, since Nigeria suffers from inadequate electricity supply; hence, there is low consumption of energy. Another study demonstrating the crowding-in effect of public investment on private investment was conducted by Abdulkarim and Saidatulakmal (2021), who examined the effects of fiscal policy on private investment in Nigeria. The study used the ARDL technique and data from 1980 to 2017.

Yousaf and Naila (2018) carried out a study to investigate the effect of the following infrastructure, namely telephone lines and length of roads, along with other control variables, on domestic investment in Pakistan, using annual data from 1975 to 2013 while adopting the ARDL technique. Their results showed that infrastructure has a generally positive and significant effect on domestic investment. Although the telephone lines variable was insignificant in the long run, it remained significant in the short run. Thus, public investment crowds in private investment in Pakistan. Conversely, the study by Abbas and Ahmed (2019) found that public investment crowds out private investment while using the vector error correction model (VECM) technique to analyse the relationship between private domestic investment and public investments in Pakistan, using

data from 1960 to 2015. The same result was obtained by Mohanty (2019), who investigated the impact of fiscal deficit on private-sector investment in India. The study found that fiscal deficit crowds out private investment both in the long run and in the short run. The study adopted the ARDL technique for the analysis and used data from 1970/71 to 2012/13. Meanwhile, the study by Akber et al. (2020) found that public investment crowds in private investment both in the long and short run in India, using the data from 1970 to 2016 and the NARDL technique.

The study by Bakare (2011) used annual data from 1978 to 2008 and the error correction model (ECM) to analyse the determinants of private domestic investment in Nigeria. The study found, among others, political instability and infrastructure, proxied by power supply, as the major determinants. The results show that public investment crowds out private investment, as shown by the negative effect of public investment in infrastructure on private investment. Likewise, Naa-Idar, Ayentimi & Frimpong (2012) found that government investment spending has a crowding-out effect where public investment negatively affects private investment in Ghana; this indicates competition for resources between the public and private sectors. The study by Mose, Jepchumba & Ouru (2020) examined the macroeconomic determinants of private domestic investment behaviours in Kenya, Rwanda and Burundi over the period from 2009 to 2018. They found that public investment crowds out private investment in these countries, as it exhibits negative and significant effects on private investment.

Several studies highlight the importance of economic infrastructure in fostering growth and private investment. However, the gap in the literature, which the current study aimed to fill, pertains to the lack of research examining the effects of critical infrastructure investment on private investment in South Africa.

3. DATA AND METHODOLOGY

3.1 Discussion of data and data sources

This study adopted quarterly data from 2006Q2 to 2023Q2, with over 60 observations. Quarterly data were used because the annual series on the variables of interest were only available from 2007, making 16 observations, which was not enough to estimate. The private sector investment-interest rate nexus has its origin in the classical and financial liberalisation theories (McKinnon, 1973; Shaw, 1973). The classical theorists argue that interest rates are negatively related to private investment. The hypothesis in classical theory is that the rate of

interest represents the cost of credit for investment. Therefore, private investment is expected to rise in response to falling interest rates, signifying an inverse relationship. The theory of financial liberalisation takes the opposite view by asserting that higher interest rates have a net positive effect on investment through saving – an effect that the proponents refer to as the "conduit effect". Increases in interest rates are expected to elicit more savings, which ultimately stimulate investment. Thus, a positive relationship is assumed between interest rates and investment. Based on the "accelerator effect", the change in gross domestic product or output, GDP growth, is one of the major determinants of investment, and it is expected to have a direct relationship with private investment.

The dependent variable is the ratio of private investment to the gross domestic product (GDP), PRV_GDP. The independent variables, which represent the investment in critical infrastructure, are total government expenditure on healthcare as a percentage of total domestic investment, HEALTH, and electricity generated and available for distribution, measured in gigawatt hours, ELECT, used as the government investment in electricity. Electricity generated and available for distribution is often used as a proxy for investment in energy infrastructure. This is because it reflects the outcomes of capital expenditures in power generation, transmission and distribution. Also, the investment in energy infrastructure normally translates into increased power generation capacity and improved transmission and distribution networks. For instance, previous studies have used this proxy, and South Africa's Renewable Energy Master Plan initiative links the generation and distribution capacity with explicit infrastructure investments (Khonjelwayo and Nthakheni, 2020; GreenCape, 2021:6, 66).

Although some limitations exist, empirical evidence and case studies strongly support electricity generated and available for distribution as a key indicator of energy sector investment. Some of the limitations are increasing electricity demand due to fuel or coal shortages, or to weather conditions, placing strain on the existing infrastructure. This results in increased generation and distribution independently of infrastructure investment. However, since data on government spending on electricity is lacking, electricity generation and distribution metrics are a good proxy for infrastructure investment because they reflect the direct impact of capital spending on electricity generation capacity and distribution efficiency.

Furthermore, investment in the energy infrastructure in South Africa has a direct impact on electricity generated and available for distribution. The government has increased investment in some key areas, such as the construction of Medupi and Kusile coal-fired power stations intended to increase electricity generated and

distributed. The Renewable Energy Independent Power Producer Procurement Programme is an investment in renewable energy, which has brought private sector investment to increase electricity generation and distribution through solar and wind generation capacity.

The control variables are GDP growth (GDPg), lending rate measured in percentage per annum, INT, and the ratio of total debt-to-GDP, DEBT. To understand the effects of GDP growth (the accelerator principle) on private investments, it is important to present data on the structure of GDP according to the expenditure method, as shown in Figure 3. Consumer spending is the highest, followed by net exports, while capital investment and government spending were quite close in some years, with the latter generally increasing more over the period under consideration. However, government spending increased significantly in 2023. This was due to the increased budget for infrastructure investment to address, especially, the challenges of persistent power cuts and a focus on improving deteriorating infrastructure, funding for the COVID-19 social relief of distress grant, and public sector wage increases, among others (Godongwana, 2023).

The study used the lending rate instead of combining it with the savings rate because of the correlation that exists between them. Higher savings lead to an increase in loanable funds, thereby lowering interest rates and encouraging more private investment. On the other hand, lower savings lead to higher interest rates, since there is a decline in loanable funds and thus less investment. Therefore, there is a direct effect of interest rates on private investment, rather than the indirect effect from savings via interest rates; hence, the choice of interest rate over savings rate.

The total debt-to-GDP ratio is an indicator of external indebtedness, which is also important in the interpretation of public investments through the crowding-in or crowding-out effect. The debt-to-GDP ratio can either cause a reduction or an enhancement in private investment. For instance, increased government borrowing can lead to competition for loans, thereby raising interest rates, and this can adversely affect private firms that depend on external financing, thus leading to a crowding-out effect. Meanwhile, deficit spending during a recession boosts aggregate demand and creates opportunities for the private sector to take advantage of the situation, thus producing a crowding-in effect.

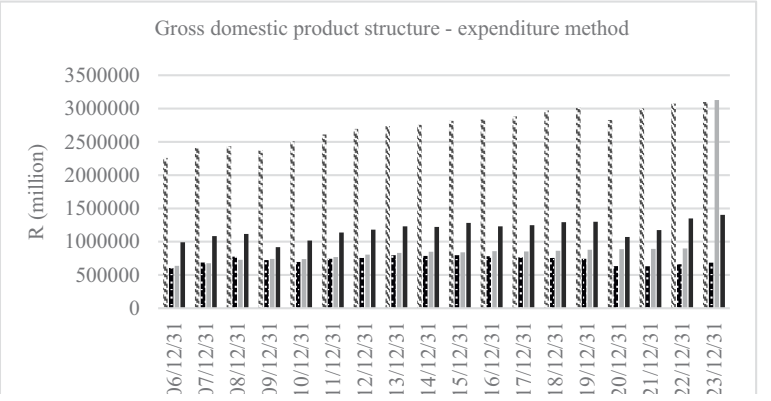

Figure 3: Gross domestic product: expenditure method
Source: Author's compilation from SARB Quarterly Bulletin, 2023

The study could not include the effects of political systems because this variable is not available quarterly, and we needed quarterly data to observe the effects on a more frequent basis and to be in line with the variables of interest. Data on total government expenditure on healthcare were sourced from the National Treasury database via Quantec. Data on electricity generated and available for distribution were obtained from Statistics South Africa (StatsSA). The lending rate was sourced from the International Financial Statistics database of the International Monetary Fund, while the ratio of private investment to the gross domestic product, GDP growth and total debt-to-GDP ratio were obtained from the South African Reserve Bank quarterly data bulletin.

However, for a robustness check, the study used a composite business confidence index that reflects the expectations of businesses regarding economic growth and their ability to produce goods and services, as well as cost implications. The variable was sourced from the Rand Merchant Bank/Bureau of Economic Research (RMB/BER) Business Confidence Index (BCI), which indicates *the percentage of businesspeople who are satisfied with prevailing conditions*. An uncertain political environment can lead to the deterioration of business confidence, thus producing negative effects on the economic environment. The instabilities arising from the political scene are associated with uncertainties regarding the functioning of institutions. Hence, the uncertainty related to the political system affects the business environment, which entrepreneurs must consider when deciding, for instance, to start or expand their businesses (Montes and Nogueira, 2022).

As earlier discussed, the expected relationship between the investments in the two critical infrastructures and private investment can either be positive or

negative, depending on whether public investment crowds in or crowds out private investment, thereby answering the first research question. The interest rate is also expected to affect private investment either positively or negatively, based on the different theories of interest rate-investment nexus, as discussed earlier, thus dealing with the second research question. Lastly, based on the accelerator effect, GDP is expected to have a direct and positive effect on private investment, which relates to the third research question.

3.2 Estimation techniques

The model and the variables defined earlier are as follows:

$$PRV\_GDP_t = f\ (HEALTH_t,\ ELECT_t,\ GDP_{gt},\ INT_t,\ DEBT_t) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\{1\}$$

ELECT in equation 1 was transformed to logarithms to avoid its being an outlier; the other variables are ratios and growth, so there was no need to log them. Therefore, the log equation model to be estimated is as follows:

$$PRV\_GDP_t = \beta_0 + \beta_1 HEALTH_t + \beta_2 logELECT_t + \beta_3 GDP_t + \beta_4 INT_t + \beta_5 DEBT + \varepsilon_t \quad ..\{2\}$$

The popular autoregressive distributed lag (ARDL) of the bounds test approach, developed by Pesaran, Shin & Smith (2001), was used to determine the short-run and long-run relationships. Thus, the study first tested all the variables for stationarity, using the Phillips-Perron (PP) test of stationarity. This was done to determine the orders of integration of each variable, since ARDL is sensitive to I(2) variables. The study also estimated the coefficients and effects of the long-run and short-run dynamics of the variables of interest on private investment. The ARDL approach is based on estimating the model using the ordinary least square (OLS) method of a conditional unrestricted error correction model (UECM) for cointegration. One of the many advantages of the bounds testing method of cointegration and the ARDL approach is that it is not compulsory to perform a stationarity test; nevertheless, the variables must not be of order two, I(2). This technique is applicable whether variables are purely I(1) or a combination of I(0) and I(1). However, if they are a combination of I(0) and I(1), the dependent variable must be I(1).

Another advantage of the ARDL technique, besides its statistical properties, is that estimations can be carried out even in the presence of endogeneity of the explanatory variables. The problem of endogeneity is common in growth models because they include the lags of both the dependent and explanatory variables. In addition, the ARDL technique is a powerful tool used to investigate both short-

run and long-run cointegrating relationships among variables (Leshoro and Wabiga 2023; Pesaran, Shin & Smith (2001).

The conditional ARDL private investment model for equation 2 is therefore expressed as follows:

$$\begin{aligned}\Delta PRV\_GDP_t = {} & \gamma_0 + \sum_{i=1}^{n} \alpha_1 PRV\_GDP_{t-i} + \sum_{i=0}^{n} \gamma_1 HEALTH_{t-i} \\ & + \sum_{i=0}^{n} \gamma_2 \Delta logELECT_{t-i} + \sum + \sum_{i=1}^{n} \gamma_3 \Delta GDP_{g(t-i)} \\ & + \sum_{i=0}^{n} \gamma_4 INT_{t-i} + \sum_{i=0}^{n} \gamma_5 DEBT_{t-i} + \beta_0 PRV\_GDP_{t-1} \\ & + \beta_1 HEALTH_{t-1} + \beta_2 ELECT_{t-1} + \beta_3 GDP_{t-1} + \beta_4 INT_{t-1} \\ & + \beta_5 DEBT + \varepsilon_t \qquad \ldots\ldots\ldots\ldots\ldots\ldots \{3\}\end{aligned}$$

In equation 3, Δ represents the first difference, the short run and long run elasticities are α_1, γ_1, …, γ_5 and β_1, …, β_5, respectively, and ε_t is the error term.

The null and alternative hypotheses, which indicate the existence or non-existence of a long-run relationship are as follows:

H_0: $\beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$

H_1: $\beta_0 \neq \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq 0$

The F-test was used to determine if cointegration existed among the variables. The interpretation of the cointegration test is as follows: If the computed F-statistic lies between the upper bound and the lower bound at a chosen significant level, there is no decision on whether there is cointegration. If the F-statistic exceeds the upper bound, the null hypothesis of "no cointegration" is rejected, and if it lies below the lower bound, the null hypothesis cannot be rejected. Critical values for lower bound or stationary variables, I(0), and the critical values for upper bound or variables integrated of order one, I(1), were developed by Pesaran, Shin & Smith (2001).

If cointegration is found, the short-run and the long-run model of equation 3 will be estimated using the standard OLS. This will allow us to obtain the speed of adjustment of economic growth back to equilibrium, as well as the short-run and long-run coefficients. Thus, the error correction model (ECM) is expressed by re-parametering equation 3 as follows:

$$\begin{aligned}\Delta PRV\_GDP_t = {} & \gamma_0 + + \sum_{i=1}^{n} \alpha_1 \Delta PRV\_GDP_{t-i} + \sum_{i=0}^{n} \gamma_1 HEALTH_{t-i} + \sum_{i=0}^{n} \gamma_2 \Delta logELECT_{t-i} \\ & + \sum_{i=1}^{n} \gamma_3 \Delta GDP_{g(t-i)} + \sum_{i=0}^{n} \gamma_4 \Delta INT_{t-i} + \sum_{i=0}^{n} \gamma_5 \Delta DEBT_{t-i} + \delta ECT_{t-1} \qquad \ldots \{4\}\end{aligned}$$

The coefficient of the error correction term (ECT), δ, measures the short-run speed of adjustment back to the long-run equilibrium. It shows how the private investment deviates from the long-run equilibrium, but gradually returns to its long-run equilibrium path. Therefore, for the economy to adjust to equilibrium, the coefficient of the ECT must be less than one, negative and must be statistically significant (Leshoro, 2020; Chirwa and Odhiambo, 2016). The ECT has a lag of one, which shows the percentage of the speed of adjustment from a shock in the previous period to the present period equilibrium (Mpatane and Eita, 2016).

4. RESULTS

Table 1 provides the descriptive statistics of the variables. Over the period under consideration, all the explanatory variables exhibited higher average, median, maximum and minimum values than did the private investment. On average, government investment in health was higher than its debt-to-GDP ratio, and over 63 000 gigawatt hours of electricity were generated and available for distribution. While the interest rate was about 10 per cent, the economy grew by only 0.4 per cent.

Table 1: Descriptive analysis: 2006Q2 to 2023Q2

	PRV_GDP	HEALTH	ELECT	INT	GDP_g	DEBT
Mean	0.028875	49.49179	63071.49	10.05055	0.436232	43.78986
Median	0.028754	42.32744	63387.00	10.00000	0.480000	42.80000
Maximum	0.035568	116.4253	68605.00	15.50000	13.73000	72.20000
Minimum	0.023581	17.48643	53858.00	7.000000	-16.89000	23.50000
Std. dev.	0.002421	26.65055	2936.445	2.006483	2.755208	15.20463
Skewness	0.201209	0.728144	-0.935108	0.933698	-2.025334	0.443217
Kurtosis	2.980889	2.440454	3.956515	3.821377	31.44979	2.077496
Jarque-Bera	0.466627	6.997365	12.68631	11.96527	2374.171	4.705737
Probability	0.791905	0.030237	0.001759	0.002522	0.000000	0.095096
Sum	1.992370	3414.933	4351933.	693.4881	30.10000	3021.500
Sum sq. dev.	0.000399	48297.11	5.86E+08	273.7663	516.1996	15720.30
Observations	69	69	69	69	69	69

PRV_INV, private investment-to-GDP ratio; HEALTH, total government expenditure on health as a percentage of total domestic investment and ELECT, electricity generated and available for distribution; INT, lending rate; GDPg, GDP growth; DEBT, the ratio of total debt-to-GDP.

Source: Author's calculation

Furthermore, kurtosis measures the sharpness (peak) or the tail of a probability distribution, with a value of 3, and the variables, private investment and investments in health and total debt-to-GDP ratio, are close to this peak, while the

kurtosis for the other variables is above this value. This is known as leptokurtic distribution because it has a higher peak (thin bell) and taller (fatter and heavier) tails than a normal distribution.

Table 2 shows the correlation probability of all the variables. The two variables of interest, namely investments in health and electricity generated and available for distribution, are statistically significant at a 1% level of significance, while only electricity generated and available for distribution is positively correlated with private investment. This means that according to the correlation probability results, electricity generated and available for distribution has a positive relationship with private investment. Meanwhile, public investments in health are inversely correlated with private investment.

According to the classical theory and Jorgenson's neoclassical theory of investment, as explained earlier, interest rates are inversely related to private investment, while the conduit effect of financial liberalisation theorists believed that interest rates have a positive effect on private investment. Hence, the correlation probability result supports the financial liberalisation theory with a highly statistically significant result. Although the correlation probability result for the GDP growth supports the acceleration theory, it is not statistically significant.

Table 2: Correlation probability

Variables	PRV_GDP	HEALTH	LOGELECT	INT	GDP_g	DEBT
PRV_GDP	1.000000					
t-Statistic	-----					
HEALTH	-0.8127	1.000000				
t-Statistic	-11.4153***	-----				
LOGELECT	0.497	-0.6031	1.000000			
t-Statistic	4.6937***	-6.1887	-----			
INT	0.7250	-0.6007	0.1855	1.000000		
t-Statistic	8.617***	-6.150696	1.545	-----		
GDP_g	0.132	-0.087	0.269	-0.006	1.000000	
t-Statistic	1.086	-0.716	2.289**	-0.047	-----	
DEBT	-0.7778	0.9746	-0.6178	-0.6035	-0.0269	1.000000
t-Statistic	-10.130***	35.622***	-6.431***	-6.196***	-0.221	-----

PRV_INV, private investment-to-GDP ratio; HEALTH, total government expenditure on health as a percentage of total domestic investment and ELECT, electricity generated and available for distribution; INT, lending rate; GDPg, GDP growth; DEBT, the ratio of total debt-to-GDP.

** 5%; *** 1%.

Source: Author's calculation

As shown in Table 3, the PP results depict that private investment, investment in health, interest rates and total debt-to-GDP ratio are integrated of order one, I(1). This means that they became stationary after the first difference. Other variables, namely electricity generated and available for distribution and GDP growth, are stationary at levels, integrated of order zero, I(0). Since the results show that the variables have a mix of order of integration – that is, I(0) and I(1) – the ARDL bounds test technique is the most applicable cointegration technique.

Table 3: Stationarity test results: Phillips-Perron

Variable	Levels	First difference	Order of integration
PRV_GDP	-2.843	18.155***	I(1)
HEALTH	-2.557	-9.060***	I(1)
logELECT	-5.139***	NA	I(0)
INT	-1.863	-3.681**	I(1)
GDP_g	-12.520***	NA	I(0)
DEBT	-2.876	-5.588***	I(1)

***1% -4.098; **5% -3.477
Source: Author's calculation

Before proceeding to test for cointegration, it is essential to determine the optimal lag and the maximum lag length selected by the Akaike information criterion (AIC) is 4. This is based on the number of regressors included in the private investment model. The optimal ARDL model selected for the equation is ARDL (3, 1, 1, 3, 1, 0). The study observed whether cointegration exists among the variables. The cointegration test results reported in Table 4 are based on 'Case 2: Restricted Constant and No Trend' of Pesaran et al. (2001), as chosen by the EViews software used. These results show that the null hypothesis of 'no cointegration' is rejected because the F-statistic, 6.541, lies above the upper bound, I(1), at all levels of significance.

Table 4: Cointegration result: ARDL bounds test

Test statistic	Value	Significance (%)	I(0) Bound	I(1) Bound
F-statistic	6.541***	10%	2.08	3
k	5	5%	2.39	3.38
		2.5%	2.7	3.73
		1%	3.06	4.15

Null hypothesis: No long-run relationships exist. *k* is the number of explanatory variables.
*** 1%.
Source: Author's calculation

Thus, there exists a long-run relationship between the ratio of private investment to GDP and all the explanatory variables. The result shows that we reject the

null hypothesis of no cointegration at all levels of significance, where the F-statistic was 6.541. We therefore proceed to estimate the short-run and long-run coefficients of each of the variables. The results of the long-run relationship are shown in table 5. The results depict that in the long run, one of the two critical infrastructures shows that government investment spending in this area will crowd in private investment and the other will crowd out private investment. While the investments in health show an inverse relationship with private investment, meaning that government investment in health does not complement private investment, it is statistically insignificant. On the other hand, the amount of electricity generated and available for distribution shows a positive relationship with private investment, implying a crowd-in effect, and it is highly statistically significant.

The effects of government investment in health – although statistically insignificant – and in electricity generated and available for distribution are quite small, indicating a weak relationship. The low effect could be due to the corruption in government, where the money allocated towards infrastructure investments does not get to be used for the intended purposes. Thus, the effects are not observed. However, increasing the gigawatt hours of electricity generated and available for distribution by a per cent will increase the share of private investment to the gross domestic product by 0.05 per cent. This finding supports the effects of the ongoing electricity problem, namely loadshedding, in the country and thus shows its importance.

On the other hand, as part of the control variables, the lending rate is consistent with the descriptive analysis result and follows the financial liberalisation theory, whereby interest rates and private investment are positively and highly statistically significant but weakly related, and the former has a net positive effect on the latter through savings. This result contradicts the findings of Leshoro and Wabiga (2023), who found an inverse relationship, although they used the same ARDL technique. This discrepancy could be because Leshoro and Wabiga (2023) used annual data, which provides less frequent changes, while the current study made use of more frequent quarterly variables. Similarly, the GDP growth depicts the accelerator effect in South Africa because not only does it show a positive relationship with private investment, but this relationship is also highly statistically significant over the period considered in the study. Finally, the debt-to-GDP ratio shows a positive relationship with private investment. That is, the increase in government spending during a recession boosts the aggregate demand and crowds in private investment. This is different from the results of Naa-Idar, Ayentimi & Frimpong (2012), where the government investment spending crowds out private investment in Ghana; thus indicating competition for resources between the public and private sectors.

Table 5: ARDL: Long run

Variable	Coefficient	Std. error	T-statistic
HEALTH	-0.0001	0.00005	-0.5868
INT	0.0005**	0.000214	2.1504
GDPg	0.0008**	0.000394	1.9748
logELECT	0.0479**	0.020274	2.3608
DEBT	0.0001	0.000115	0.5678
C	-0.5064**	0.226560	-2.2351

** 5%.
Source: Author's calculation

The short-run ARDL results provided in Table 6 show that while the investment in the two critical infrastructure variables crowds out private investment in the short run and in the current period, electricity is not statistically significant. Since the effects of infrastructure cannot be immediate in the short run because variables are in the differenced form, the short-run results should not focus on the signs of the parameters in explaining the private investment and critical infrastructure investment nexus.

When variables are differenced, the long-run information is lost and investing in infrastructure in the current period cannot yield an effect on the percentage of investment to gross domestic product. The only sign that should be considered and interpreted in the short run is the error correction term. In this case, the error correction term of -0.419 is reasonably high and satisfies all the conditions that it must be less than one, statistically significant and carry a negative sign. This implies the adjustment back to the long-run equilibrium, where 42% of disequilibrium is corrected quarterly. Thus, if the ratio of private investment to GDP deviates from its long-run equilibrium with the other variables in the preceding quarter, equilibrium will be restored in the following quarters at the rate of 42%.

Table 6: ARDL: Short run

Variable	Coefficient	Std. error	T-statistic
ΔPRV_GDP(-1)	-0.4214***	0.0886	-4.7532
Δ(PRV_GDP(-2)	-0.3215***	0.0787	-4.0838
ΔHEALTH	-0.0006***	2.26E-05	-3.0826
ΔlogELECT	-0.0050	0.0035	-1.4531
ΔINT	-0.0002	0.0003	-0.6877
ΔINT(-1)	-0.0005	0.0004	-0.1226
ΔINT(-2)	0.0013***	0.0003	4.1427
Δ(GDPg)	0.0002***	4.04E-05	5.8828
ECM(-1)	-0.419***	0.0586	-7.1533

*** 1%
Source: Author's calculation

The results from the robustness check model showed that the composite business confidence index is insignificant in the case of South Africa. According to the results (not shown), the variable was automatically dropped from the parsimonious model in the short run, implying that it is economically insignificant in the short run and statistically insignificant in the long run.

Thus, the study answered the three research questions set out above, namely:

1. Does government investment in each of these critical infrastructures complement or compete with the private investment in South Africa? In other words, is government spending crowding in and thus promoting the expansion and development of the private sector, or is it crowding out private investment in South Africa?
   - Public investment in electricity generated and made available for distribution crowds out private investment in the short run, while it crowds in private investment in the long run. It is, however, statistically insignificant in the short run but statistically significant in the long run and in the period under consideration.
   - Although public investment in health crowds out private investment in the short run and in the long run, it is statistically significant in the short run and statistically insignificant in the long run.
2. To what extent do changes in interest rates influence the percentage of private investment to the GDP?
   - They are positively and highly statistically significant, but weakly related in the long run.
   - They are a mixture of statistically significant and insignificant in the short run, while also depicting a mixed relationship with private investment.
3. And lastly, does the acceleration theory hold for South Africa?
   - GDP growth shows a positive relationship with private investment, and it is statistically significant both in the long run and the short run. This shows that the acceleration theory holds for South Africa.

The results further show that the model passed the battery of diagnostic tests of normality, heteroscedasticity and serial correlation, as shown in Table 7, where we failed to reject all the null hypotheses. Lastly, the graph presented in Figure 4 shows that the estimated cointegration relation model is appropriate. This is because the graph reverts to equilibrium, which is zero. Therefore, our results are reliable and well-specified.

Table 7: Diagnostic tests

Test	Null hypothesis	Probability
Normality test: Jarque-Bera	The error term is normally distributed.	1.0498 (0.592)
Serial correlation LM tests: Breusch-Godfrey, F(2,49)	No serial correlation	0.528 (0.593)
Heteroscedasticity test: Breusch-Pagan-Godfrey, F(14,51)	Homoscedasticity	0.8551 (0.609)
Ramsey RESET test: Functional form (1,50)	Stable model	2.2684 (0.138)

Source: Author's calculation

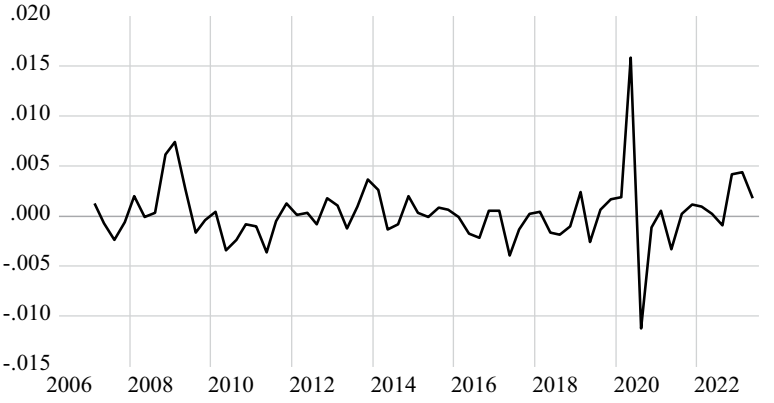

Figure 4: Co-integration graph for private investment model
Source: Author's calculation

5. CONCLUSIONS

This study contributes to the understanding of the complex relationship between critical infrastructure investment and private investment in South Africa. The study used quarterly data spanning the period from 2006Q2 to 2023Q2 and adopted the auto-regressive distributed lag technique. Based on the econometric analysis, government spending on electricity generated and made available for distribution was found to compete with private investment, but it is statistically insignificant in the short run, whereas it complements private investment in the long run and is highly statistically significant. The same result was found by Ahmed et al. (2018), who analysed the critical importance of energy infrastructure for domestic investments in Nigeria. Their result showed that public investment crowds in private investment, but this is statistically insignificant. Public investment in health competes with private investment in

the long run and the short run; moreover, the effect is statistically significant in the short run and statistically insignificant in the long run. This is different from the study by Maluleke, Odhiambo & Nyasha (2023), who found that aggregate public investment competes with private investment in South Africa in the long run and complements it in the short run.

The effects of the critical infrastructure variables on the ratio of private investment to GDP are very small, indicating a weak relationship, although they are highly statistically significant. This corroborates the findings of Henckel and McKibbin (2017), who argued that the misallocation of infrastructure spending leads to a weak or no crowd-in effect on private investment. It is important to note that the excluded variables, such as political instability or corruption, given the reasons provided above, could affect the results through the weak relationship that the selected variables depict with private investment. Countries with better governance tend to encourage private investment, thus, increasing government spending will crowd in private investment, while weak institutions amplify crowd-out effects on private investment, as found by Pritchett (2000), Nguyen (2022) and Esfahani and Ramírez (2003) for globalised world and developing countries.

The study used a composite business confidence index, which reflects the expectations of businesses regarding economic growth and their ability to produce goods and services, as well as cost implications, as the robustness check. An uncertain political environment can lead to the deterioration of business confidence, thus producing negative effects on the economic environment. However, the results show that the composite business confidence index variable was insignificant in the case of South Africa. The variable was automatically dropped from the parsimonious model in the short run, which implies that it is economically insignificant in the short run and statistically insignificant in the long run.

The study's robust methodology and comprehensive analysis provide valuable insights for policymakers and stakeholders seeking to foster economic growth through strategic infrastructure investments. The findings underscore the importance of well-targeted infrastructure investments in driving private-sector development. The results indicate a need for focused consideration of infrastructure investment to achieve a substantial economic impact on private investment, thereby contributing to economic growth and development. The government should ensure that the funds earmarked for investment in infrastructure are apportioned correctly.

While this study provides a comprehensive analysis, it is not without limitations. Future studies could delve deeper into specific sectors or incorporate additional variables by using the infrastructure index to enhance the understanding of private investment dynamics. The current study examined the investment in infrastructure using electricity generated and distributed instead of loadshedding, because the focus was not on the effect of loadshedding but on infrastructure. However, future studies may investigate the effect of loadshedding on infrastructure. Also, investigating the impact of legal and regulatory frameworks on private investment, which is beyond the scope of this study, is another limitation. Addressing these limitations in future studies will strengthen the knowledgebase for policymakers and researchers interested in fostering sustainable economic development through strategic infrastructure investments.

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Conflict of interests

The authors declare there is no conflict of interest.

REFERENCES

Abbas, A., & Ahmed, E. (2019). Private, public and foreign investment nexus in Pakistan: An empirical analysis of crowding-in/out effects. *Forman Journal of Economic Studies*, *15*, 181-208. https://doi.org/10.32368/FJES.20191508

Abdulkarim, Y., & Saidatulakmal, M. (2021). The impact of fiscal policy variables on private investment in Nigeria. *African Finance Journal*, *23*(1), 41-55. https://journals.co.za/doi/full/10.10520/ejc-finj_v23_n1_a3

Adugna, H. (2013). Determinants of private investment in Ethiopia. *Journal of Economics and Sustainable Development*, *4*(20). www.iiste.org ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online). https://core.ac.uk/download/pdf/234646198.pdf

Ahmed, A. O., Olusola, A. T., Taiwo, M. A., & Wole, A. M. (2018). Energy infrastructure and growth of domestic investment in Nigeria: An ARDL approach.*Kuwait Chapter of the Arabian Journal of Business and Management Review*,*7*(3), 14-22. https://platform.almanhal.com/Files/2/120284

Akber, N., Gupta, M., & Paltasingh, K. (2020). The crowding-in/out debate in investments in India: Fresh evidence from NARDL application. *South Asian*

Journal of Macroeconomics and Public Finance, *9*(2), 167-189. https://doi.org/10.1177/2277978720942676

Bakare, A.S. (2011). The determinants of private domestic investment in Nigeria.*Far East Journal of Psychology and Business*,*4*(3), 27-37. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=aead5e39863797f3ce632bbc39d62e6ebb25c189

Barro, R. J. (1990). *Government spending in a simple model of endogenous growth. Journal of Political Economy, 98*(5), S103–S125. https://doi.org/10.1086/261726

Batu, M. M. (2016). Determinants of private investment: A systematic review. *International Journal of Economics, Finance and Management Sciences*,*4*(2), 52-56. https://doi.org/10.11648/j.ijefm.20160402.13

Bengoa, M., & Sanchez-Robles, B. (2003). Foreign direct investment, economic freedom and growth: New evidence from Latin America.*European Journal of Political Economy*,*19*(3), 529-545. https://doi.org/10.1016/S0176-2680(03)00011-9

Chirwa, T.G., & Odhiambo, N.M. (2016). What drives long run economic growth? Empirical evidence from South Africa. *International Economics, 69*(4), 425–452.

Eduardo, C., & Christian, D. (2011). Public investment in developing countries: A blessing or a curse? *Journal of Comparative Economics, 39*(1), 65-81. https://doi.org/10.1016/j.jce.2010.10.001

Esfahani, H. S., & Ramírez, M. T. (2003). Institutions, infrastructure, and economic growth.*Journal of development Economics*,*70*(2), 443-477.

Global Infrastructure Hub. (2023). *Private sector roles and participation*. https://inclusiveinfra.gihub.org/action-areas/private-sector-roles-and-participation/

Godongwana, E. (2023). *Budget speech. National Treasury, Republic of South Africa*. https://www.treasury.gov.za/documents/National%20Budget/2023/speech/speech.pdf

Government Gazette. (2022). *South Africa's National Infrastructure Plan 2050*. No 46033.

GreenCape. (2021). *The South African Renewable Energy Master Plan: Emerging Actions Discussion Document*. Updated November 2021.

Hailu, D. B., & Debele, F. (2015). The effect of monetary policy on the private sector investment in Ethiopia: ARDL co-integration approach. *Economics, 4*(2), 22-33. https://doi.org/10.11648/j.eco.20150402.12

Henckel, T., & McKibbin, W. J. (2017). The economics of infrastructure in a globalized world: Issues, lessons and future challenges.*Journal of Infrastructure, Policy and Development*,*1*(2), 254-272.

Infrastructure South Africa. 2023. *Infrastructure Investment Plan*. https://infrastructuresa.org/

Khonjelwayo, B., & Nthakheni, T. (2020). Investment in electricity distribution capital infrastructure in South Africa: The role of regulation.*South African Journal of Economic and Management Sciences*,*23*(1), 1-10.

Leshoro, T. L. (2020). Impacts of productive and recurrent public expenditure on economic growth in South Africa: An analysis using the autoregressive distributed

lag–error correction model. *Journal of Economic and Financial Sciences*, *13*(1), 12. https://doi.org/10.4102/jef. v13i1.563

Leshoro, T. L. A., & Wabiga, P. (2023). The asymmetric effects of interest rates on private investment in South Africa.*Acta Universitatis Danubius. Œconomica*,*19*(3), 161-182. https://www.ceeol.com/search/article-detail?id=1165408

Maluleke, G., Odhiambo, N. M., & Nyasha, S. (2023). Symmetric and asymmetric impact of public investment on private investment in South Africa: Evidence from the ARDL and non-linear ARDL approaches. *Cogent Economics & Finance*, *11*(1), 2189560, https://doi.org/10.1080/23322039.2023.2189560

McKinnon, R. I. (1973). *Money and capital in economic development.* The Brookings Institution, Washington DC.

Mohanty, R. K. (2019). Does fiscal deficit crowd out private corporate sector investment in India? *The Singapore Economic Review*, *64*(5), 1201-1224. https://doi.org/10.1142/S0217590816500302

Molapo, S., & Damane, M. (2015). Determinants of private investment in Lesotho, 1982-2013. *European Scientific Journal*, *11*(34). https://core.ac.uk/download/pdf/328025254.pdf

Montes, G. C., & Nogueira, F. D. S. L. (2022). Effects of economic policy uncertainty and political uncertainty on business confidence and investment.*Journal of Economic Studies*, *49*(4), 577-602. https://doi.org/10.1108/JES-12-2020-0582

Mose, N., Jepchumba, I., & Ouru, L. (2020). Macroeconomic determinants of domestic private investment behaviour. *African Journal of Economics and Sustainable Development*, *3*(2), 30-37. https://ssrn.com/abstract=3904215

Mpatane, L.M., & Eita, J.H. (2016). Manufactured exports and economic growth in Swaziland: Autoregressive Distributed Lag (ARDL) bound testing approach. *GAI International Academic Conferences Proceedings* (pp. 272–280), 22nd–25th May 2016, New York, USA.

Naa-Idar, F., Ayentimi, D. T., & Frimpong, J. M. (2012). A time series analysis of determinants of private investment in Ghana (1960-2010). *Journal of Economics and Sustainable Development*, *3*(13).https://ssrn.com/abstract=2549491

Nguyen, B. (2022). The crowding-out effect of public debt on private investment in developing economies and the role of institutional quality.*Seoul Journal of Economics*,*35*(4).

Nyoni, T., & Bonga, W. G. (2017). An empirical analysis of the determinants of private investment in Zimbabwe.*Dynamic Research Journals' Journal of Economics & Finance (DRJ-JEF)*,*2*(4), 38-54. https://ssrn.com/abstract=2960558

Omitogun, O. (2018). Investigating the crowding out effect of government expenditure on private investment.*Journal of Competitiveness*,*10*(4), 136-150. https://doi.org/10.7441/joc.2018.04.09

Omojolaibi, J. A., Okenesi, T. P., & Mesagan, E. P. (2016). Fiscal policy and private investment in selected West African countries. *CBN Journal of Applied Statistics*, *7*(1), 277-309. https://www.econstor.eu/bitstream/10419/191684/1/868322709.pdf

Perkins, P., Fedderke, J., & Luiz, J. (2005). An analysis of economic infrastructure investment in South Africa.*South African Journal of Economics*,*73*(2), 211-228. https://doi.org/10.1111/j.1813-6982.2005.00014.x

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bound testing approaches to the analysis of level relationships. *Journal of Applied Econometrics, 16*(3), 289-326. https://doi.org/10.1002/jae.616

Pritchett, L. (2000). The tyranny of concepts: CUDIE (cumulated, depreciated, investment effort) is not capital.*Journal of Economic Growth*,*5*, 361-384.

Şen, H., & Kaya, A. (2014). Crowding-out or crowding-in? Analysing the effects of government spending on private investment in Turkey. *Panoeconomicu*, *61*(6), 631-651. https://doi.org/10.2298/PAN1406631S

Shaw, E. (1973). *Financial deepening in economic development*. Oxford University Press. New York, USA.

Sineviciene, L., & Vasiliauskaite, A. (2012). Fiscal policy interaction with private investment: The case of the Baltic states. *Inzinerine Ekonomika-Engineering Economics*, *23*(3), 233-241. https://doi.org/10.5755/j01.ee.23.3.1934

South African Reserve Bank (SARB). (2023). *Quarterly Bulletin*. https://www.resbank.co.za/en/home

Statistics South Africa. (2022). *Labour market dynamics in South Africa*. Labour Statistics. https://www.statssa.gov.za/

The Wall Street Journal. (2008). NBER Makes It Official: Recession Started in December 2007. National Bureau of Economic Research. https://www.wsj.com/articles/BL-REB-2390

Wai, U. T., & Wong, C. H. (1982). Determinants of private investment in developing countries.*The Journal of Development Studies*,*19*(1), 19-36. https://doi.org/10.1080/00220388208421848

Yousaf, A., & Naila, E. R. U. M. (2018). The role of infrastructure in promoting domestic investment in Pakistan. *Pakistan Journal of Applied Economics*, *28*(1), 493-512.

ЈАВНИ И ПРИВАТНИ СЕКТОР НА ДЈЕЛУ: РАЗОТКРИВАЊЕ ДИНАМИКЕ УЛАГАЊА У ИНФРАСТРУКТУРУ У ЈУЖНОАФРИЧКОЈ РЕПУБЛИЦИ

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САЖЕТАК

Приватне инвестиције играју кључну улогу у стварању радних мјеста и економском расту. Имајући у виду њихов значај, ова студија је анализирала динамику односа између јавних инвестиција, посебно у кључну инфраструктуру, и приватних инвестиција – да ли се оне међусобно допуњују или конкуришу једна другој. Истраживање је било усмјерено

на сложени однос између приватних и државних инвестиција у критичну инфраструктуру у области здравства и производње електричне енергије у Јужноафричкој Републици. Користећи квартално временске серије података у периоду од другог квартала 2006. године до другог квартала 2023. године, примијењена је метода ауторегресивног расподијељеног кашњења (ARDL). Према економетријској анализи, државна потрошња у здравству и производњи електричне енергије допуњује приватне инвестиције. Утицај инвестиција у критичној инфраструктури на однос приватних инвестиција према БДП-у је релативно низак, али статистички веома значајан. Резултати наглашавају важност добро усмјерених инвестиција у инфраструктуру као покретача развоја приватног сектора. У цјелини, ова свеобухватна анализа доприноси бољем разумијевању сложене динамике између јавних и приватних инвестиција у контексту развоја критичне инфраструктуре у Јужноафричкој Републици. Налази ове студије су од суштинског значаја за доносиоце одлука, инвеститоре и истраживаче који настоје да унаприједе економску политику и подстакну одрживи економски развој у земљи.

Кључне ријечи: *АРДЛ, производња електричне енергије, здравство, инфлација, инфраструктура, инвестиције.*

MUTUAL FEEDBACK SHOCKS BETWEEN ICT AND POVERTY IN SOUTH AFRICA

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ABSTRACT

This study delves into the intricate relationship between information and communication technology (ICT) and poverty in the context of South Africa, exploring the mutual feedback shocks that dynamically shape both domains using data from World Development Indicators for the period 1990-2021. Employing a comprehensive analytical framework, the study investigates how advancements in ICT, an index of computers, mobile phones and internet, influence poverty rates, proxied by head count ratio, in the short run and long run and, conversely, how the socio-economic conditions associated with poverty feedback into the ICT landscape. Correlation test, granger causality test, co-integration test and VAR/VECM models were utilised in an endeavor to seek answers to the questions. The empirical results showed that there is a relationship, with ICT truly causing poverty in South Africa. The VAR/VECM established that there exists a long run relationship between ICT and poverty in South Africa, at 10% significance level, and the variance decomposition further confirmed some significant short run feedback shocks between ICT and poverty. It is highly recommended that the South African government put in place sound and friendly ICT policies, more especially to the marginalised and poor townships where a lot of SMMEs are trying to thrive. Skills development and an increase in public expenditure on ICT is recommended, as an effort to eradicate poverty through ICT. Through empirical analysis, the complex dynamics that underscore this mutual feedback loop were exposed, shedding light on the potential mechanisms for breaking the cycle of poverty through strategic ICT interventions. This research not only contributes to the academic discourse on technology and development but also provides practical insights for policymakers and stakeholders seeking sustainable strategies to address poverty challenges in South Africa.

1. INTRODUCTION

The global challenge of extreme poverty, affecting approximately 9.2% of the world's population, resonates profoundly in sub-Saharan Africa, notably in South Africa, where a significant portion of this burden is felt (World Bank, 2020). Amidst this socioeconomic landscape, the transformative impact of information and communication technology (ICT) emerges as a beacon of hope in the post-2000 era. The escalating significance of ICT as a driver of economic development has garnered considerable attention, emphasising its potential role in poverty alleviation (Masango, Van Ryneveld & Graham, 2022). Recognising this potential, the Southern African Development Community (SADC) took a decisive step in 2001 by endorsing regional ICT policies and strategies. This commitment was fortified by substantial investments aimed not only at harnessing ICT for economic growth but also as a tool to mitigate the pervasive challenge of poverty (Olamide et al., 2022). This study embarks on a comprehensive exploration to discern the intricate relationship between ICT and poverty. Beyond establishing a correlation, our focus extends to unraveling the existence of mutual feedback shocks between ICT and poverty. By delving into this dynamic interplay, the study aims to provide valuable insights that can inform and shape effective policies for sustainable development, with a dual objective of poverty reduction and economic advancement.

Against this background, the objectives of the study henceforth are to find out if there is a relationship between ICT and poverty in South Africa and also determine the causal relationship between the two. The study aims to find out if there is a long run and short run equilibrium between ICT and poverty in South Africa as well as to find out if there are mutual feedback shocks between ICT and poverty in the same country.

The rest of the paper is structured as follows: section 2: overview of ICT and poverty in South Africa, section 3 reviews the materials and methods, while section 4 presents the results. Section 5 details discussions and conclusions while section 6 is recommendations.

2. OVERVIEW OF ICT AND POVERTY IN SOUTH AFRICA

The historical underpinnings of poverty in South Africa are deeply rooted in the Apartheid Era, characterised by systemic racial segregation and discrimination. While the post-apartheid era witnessed significant socio-political changes, poverty has persisted, prompting a closer examination of its contemporary manifestations.

Statistical evidence underscores the gravity of the poverty challenge in RSA. According to StatsSA (2022a, 12), an estimated 46% of South Africans experienced poverty between 2010 and 2014. World Bank (2020) data paints a stark picture, revealing that 55.5% of the population (30.3 million people) lived in poverty at the national upper poverty line (ZAR 992). Concurrently, 13.8 million people (25%) grappled with food poverty in post-2015. International poverty standards of $1.90 and $3.20 per person per day (2011 PPP) depict escalating trends, further emphasising the multifaceted nature of poverty in the nation.

South Africa's Gini score of 63 in 2022 signifies its status as one of the most unequal nations globally. Since 1994, income polarisation has intensified, characterised by high levels of chronic poverty, a limited middle class, and a concentration of high earners. This socio-economic context sets the stage for an exploration of how ICT intersects with and potentially influences these existing dynamics.

Against this backdrop, the South African government has grappled with the challenge of incorporating ICT into its developmental agenda. Early critiques, such as those by Moodley (2005), pointed to rigidity and hegemony in the government's approach toward ICT. Subsequent assessments by Masango (2017) underscored a perceived negligence in ICT policies, particularly in the promotion of small, micro and medium enterprises (SMMEs) in crucial urban centers like Soweto. These insights illuminate the complexities of integrating ICT as a catalyst for economic development and poverty reduction.

The overarching debate on the role of ICT in poverty reduction in RSA is dichotomous. Left-leaning perspectives, typified by scholars like Thabo (2003), Erum and Hussain (2019), and Raheem, Tiwari & Balsalobre-Lorente (2020), express reservations about the potential adverse effects of ICT on poverty alleviation. Conversely, right-leaning scholars, including David (2019), Fernandez-Portillo et al. (2019), Akinboade et al. (2022), Masango, Van Ryneveld & Graham (2022), and Olamide et al. (2022), advocate for the positive contributory role of ICT in fostering economic growth and development.

Within this dynamic landscape emerges the research gap, which is the need for a nuanced investigation into the relationship between ICT and traditional poverty indicators. This study aims to explore causal mutual shocks between ICT and poverty, providing a robust foundation for the formulation of targeted policies and measures aimed at addressing the persistent challenge of poverty in the RSA context.

3. MATERIALS AND METHODS

This study hinges its theoretical literature on the efforts by Schumpeter's Technological Theory. According to Schumpeter (1928), the economy undergoes a process of "creative destruction" whereby weaker sectors are eliminated and new ones are created as a result of the diffusion of new ideas and technology. Thus, according to Schumpeter's theory, the concept of technological evolution goes beyond the straightforward implementation of novel processes to include the development of new markets, distribution networks, and raw material sources. However, a number of other theories such as Romer (1986), Landau and Rosenberg (1986) were able to build on Schumpeterian theory.

A number of theoretical studies such as leftists believe that ICT constitutes additional expenses to the poor and therefore adds to their level of poverty (Thabo, 2003). They found a direct relationship between a low level of poverty and higher usage of ICT and vice versa (May, 2012 and Howard & Horn, 2014). Erum and Hussain (2019) noted that ICT plays a significant contribution in nexus between corruption and economic growth within Organisation of Islamic Countries (OIC). However, rightists such as Spiezia (2013), Ishida (2015), Saidi and Mongi (2018), David (2019), Fernandez et al, (2019), Masango, Van Ryneveld & Graham (2022) and Olamide et al (2022) supported the notion that there is a relationship between ICT and poverty in South Africa.

The variables contained in this study, their description and their sources are expressed in the Table 1 below:

Table 1: Variable descriptions and source

Variable	Description/measurement	Source of data
Information and Communication Technology (ICT)	Index of mobile phone, landline phone and internet penetration	
Poverty (POV)	Headcount ratio	
Economic Growth (EG)	Real Gross Domestic Product	
Human Development (Index) (HD)	Composite summary of a country's average achievements in three basic aspects of human development: health, knowledge and standard of living.	World Development Indicator (2022)
Income (INC)	Income earned per average household	
Inequality (INEQ)	Gini coefficient	
Unemployment (UNEMP)	Percentage of people in the labour force who are unemployed	

Source: World Development Indicators (2022)

Poverty (POV): This study will use the headcount ratio as a proxy for poverty. National poverty headcount ratio is the percentage of the population living below the national poverty line(s). In South Africa, the poverty headcount ratio at National Poverty Lines is a percentage of population data which is updated yearly, averaging 58.800 % from Dec 2005 to 2014, with 4 observations. The data reached an all-time high of 66.6 % in 2005 and a record low of 53.2 % in 2010

Information and Communication Technology (ICT): Moodley (2005) has since indicated that ICT is best measured with an index of mobile phone, landline phone and internet penetration, which was adopted in this study. Caceres (2007) used mobile phone, computers and internet as proxy for ICT. In this study, landline has been factored in instead of computers. Mobile phones, landline phones, and the internet are regarded as general purpose technologies (GPTs) and are considered engines of long-term growth and sources of economic transformation and sustainability due to their everyday use. The significance of using the three GPTs lies in the fact that all other devices, applications, mechanical systems, and ICT-related knowledge converge upon these three, making ICT effective.

Control Variables: In this study, control variables were harnessed, and these include economic growth (EG), human development (HD), income (INC), inequality (INEQ) and unemployment (UNEMP). Economic growth, human development, and income have traditionally been found to have an inverse relationship with poverty. However, unemployment and inequality have positive relationship with poverty. The significance of control variables is to enhance the internal validity of the study by limiting the influence of confounding and other extraneous variables

Model Estimation

In order to address these specified research areas in South Africa from 1990 to 2021, this study used the correlation, Granger causality and VAR(VECM) instruments. Both the development of ICT and the fourth economic revolution, marked by the digital explosion, occur during this time. The variables are poverty (POVT), information and communication technology (ICT), economic growth (EG), human development (Index) (HD), income (INC), inequality (INEQ), unemployment (UNEMP). The main core variables of concern are poverty and information and communication technology. However, an array of control variables have been included too, such as economic growth (EG), human development (HD), income (INC), inequality (INEQ) and unemployment (UNEMP). The significance of control variables is to enhance the internal validity of the study by limiting the influence of confounding and other extraneous variables.

By facilitating the estimation of short- and long-term correlations and model parameters, the VECM model was instrumental in achieving the second empirical objective of this study (Tripathi, 2011; Bennet, Kallus & Schnabel, 2019). The model used to investigate relationship ICT and poverty in South Africa is specified below:

$$Y_{it} = X_{it}\beta_1 + X_{it}\beta_2 + X_{it}\beta_3 + X_{it}\beta_p + u_{it} + \varepsilon_{it} \quad \text{.....(1)}$$

Where Y_{it} represents the endogenous variable, poverty. Exogenous variables in the model were: ICT, economic growth, human development, income, inequality and unemployment. These variables are vital when it comes to poverty and are supported by the fact that all of them have an impact on the wellbeing of people. X_{it} represents vector of exogenous covariates. X_{it} represents external variables that influence the dependent variable but are not influenced by it within the model's framework. These covariates are crucial for controlling external factors that may affect the model's accuracy. The variables u_{it} and ε_{it} denoted vectors of dependent variables, specific fixed effects and idiosyncratic errors. Since the research used the VAR model, it is essential to present the model.

$$\begin{aligned}\Delta POVT_{it} &= \gamma_0 + \gamma_1 \Delta ICT_{it-1} + \gamma_2 \Delta EG_{it-1} + \gamma_3 \Delta HD_{it-1} + \gamma_4 \Delta INC_{it-1} \\ &\quad + \gamma_5 \Delta INEQ_{it-1} + \gamma_6 \Delta UNEMP_{it-1} + \varepsilon_{it} \quad \text{.....(2)}\end{aligned}$$

Where POVT is represented by head count ratio, ICT represents information and communication technology, EG = economic growth, HD = human development, INC = income, INEQ = inequality, UNEMP = unemployment

The null hypothesis is there is no relationship between ICT and poverty in South Africa, while the alternative hypothesis is that there is a relationship between ICT and poverty in South Africa. Further hypotheses assess the causal relationship, long-run and short-run equilibrium, as well as mutual feedback effects between ICT and poverty, in line with Mateko (2024). The research concentrated on the resulting impulse-response functions, which estimated how certain system variables would respond to changes in another system variable while holding all other shocks at zero. To isolate the shocks to one of the VAR errors, it was required to divide the residuals in a way that makes them orthogonal because the variance-covariance matrix of the errors was unlikely to be diagonal.

The current VAR model utilises a Cholesky decomposition of the residual variance-covariance matrix to achieve this (Seleteng, 2016). It is customary to use a certain ordering and assign any correlation between the residuals of

any two items to the variable that appears first in the ordering. The underlying premise is that variables in the beginning of the ordering have a simultaneous and delayed impact on variables that follow them, while the latter variables only have a delayed impact on the former.

Correlation, causality, unit root, lag selection, co-integration, VAR estimation, impulse response and variance decomposition tests were performed while the VAR model was used. To identify statistical differences, t-tests were also used. All of these tests were conducted to determine the direction of causality, determine whether the variables had a short term and/or long-term link, and determine whether the time series variables or factors were non-stationary.

4. RESULTS

The empirical results were analysed and presented, following the series of tests performed. The researcher, in attempt to answer the research questions, performed correlation analysis, causality test, unit root test for stationarity, lag selection test, co-integration test, VAR modelling, impulse responses test and lastly variance decomposition.

An ordinary covariance analysis was carried out using correlation of the variables. The variables of interest being ICT and poverty, and the results showed a correlation coefficient of -0.74 between ICT and POVT. This means that there is a negative moderately strong relationship between poverty and ICT. The results may mean that an increase in ICT may actually mean a decrease in poverty, which is a plausible gesture from the results. However, correlation analysis alone may not give us a true picture of what causes what, and degree of causation, hence further statistics have to be checked too.

The order of integration of each variable was carried out, since the ARDL uses each variable at the level at which it is stationary. To test the stationarity of the series, the study uses the Augmented Dickey Fuller (ADF) unit root testing procedure (Dickey and Fuller, 1979). After testing for unit root, the results were presented in the table below. The results will communicate on whether the variables are non-stationary or stationary. If they are non-stationary, then a vector autoregressive model will be utilised to check the impact of ICT on POVT in South Africa.

Table 2: Unit root tests (ADF Tests)

Series	Prob.	Lag	Max Lag	Obs
D(EG)	0.0050***	0	6	30
D(HD)	0.0046***	5	6	25
D(ICT)	0.0076***	0	6	30
D(INC)	0.0196**	0	6	30
D(INEQ)	0.0257**	0	6	30
D(POVT)	0.0871*	0	6	30
D(UNEMP)	0.0707*	0	6	30

***, **, * indicates being significant at 1%, 5% and 10% respectively

Source: Author's calculation (2023)

Of the seven variables tested for stationarity, they were all found to be significant at least at 10% level. Since all are only significant at first difference, vector autoregressive (VAR) model will be appropriate for evaluation the impact of ICT on poverty in South Africa.

4.1 Lag selection criterion

Using the AIC, symmetric lag VAR models are easily estimated. Since the specification of all equations in the model is the same, estimation via ordinary least squares yields efficient parameter estimates. The table below shows results from lag selection conducted.

Table 3: Lag selection tests

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1644.408	NA	1.53e+39	110.0939	110.4208	110.1985
1	-1408.192	346.4495*	6.39e+33*	97.61282*	100.2284*	98.44957*

VAR Lag Order Selection Criteria
Endogenous variables: POVT ICT EG HD INC INEQ UNEMP
* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)

Source: Author's calculation (2023)

Using the data from South Africa, with 31 observations from 1990 to 2021, a lag selection criterion was used and the results showed that lag 1 is optimum and appropriate.

Gujarati (2022) noted that Granger causality tests whether one variable in a linear relationship can be meaningfully treated as the dependent variable and the other as the independent variable, whether the relationship is bidirectional, or

whether no functional relationship exists at all. A pairwise granger causality test was carried out to check for causality between ICT and poverty using stationary data.

Table 4: Causality tests

Null Hypothesis:	Observations	F-Statistic	Prob.
POVT does not Granger Cause ICT	31	1.22770	0.31
ICT does not Granger Cause POVT		4.14111	0.028

Source: Author's calculation (2023)

Using data from South Africa covering the period from 1990 to 2021, with a sample of 31 observations, Granger causality testing between POVT and ICT revealed a p-value of 0.028, which is below the 0.05 significance level. This result indicates that ICT Granger-causes poverty in South Africa, as the null hypothesis—that ICT does not Granger-cause POVT—can be rejected.

Yucel (2022) defined co-integration as a technique used to find a possible correlation between time series processes in the long term. In this context, the co-integration test was applied and the results showed that all P values of the seven variables were below 0.1, or were significant at 10% level. The results showed that, there is a presence of long-run relationships since most of the tests are significant at least at 10% and restricted VECM used, as shown in Table 5 below:

Table 5: Co-integration results

Hypothesised No. of CE(s)	Eigenvalue	Max-Eigen/Statistic	Critical Value	Prob.**
None *	0.991487	142.9853	50.59985	0.0000
At most 1 *	0.930920	80.17450	44.49720	0.0000
At most 2 *	0.894368	67.43375	38.33101	0.0000
At most 3 *	0.847581	56.43369	32.11832	0.0000
At most 4 *	0.755900	42.30526	25.82321	0.0002
At most 5 *	0.649327	31.43707	19.38704	0.0006
At most 6 *	0.349425	12.89694	12.51798	0.0432

Max-eigenvalue test indicates 7 cointegrating eqn (s) at the 0.05 level,

**MacKinnon-Haug-Michelis (1999) p-values

Source: Author's calculation (2023)

Vector error estimates

Table 6: VECM results

VEC Estimates	Coefficient	P-value	T-Statistic
POVT (-1)	1		
ICT (-1)	0.140127	(0.03715)**	[3.77217]
EG (-1)	1.12E-11	(3.5E-11)***	[0.321421]
HD (-1)	-1.70E-11	(5.3E-07)***	[-3.21421]
INC (-1)	-0.016804	(0.00167)***	[-10.0726]
INEQ (-1)	1.047404	(0.08743)*	[11.9796]
UNEMP (-1)	-2.698636	(0.14377)	[-18.7710]
C	85.68509		

Note: (*), (**) and (***) indicate 1%, 5% and 10% significance level, respectively

Source: Author's calculation (2023)

The Table 6 above shows that a percentage change in ICT associated with a 0.14 % increase in POVT on average in the short run. A percentage change in EG associated with a 1.12 % increase in POVT on average in the short run. A percentage change in HD associated with a 1.7 % decrease in POVT on average in the short run. A percentage change in INC associated with a 0.01 % decrease in POVT on average in the short run. A percentage change in INEQ is associated with a 1.04% increase in POVT on average in the short run. A percentage change in UNEMP associated with a 02.69 % decrease in POVT on average in the short run. The constant or intercept is 85.68. ICT is statistically significant at 5% significant level, while EG, HD and INC are all significant at 1% level of significant. INEQ is significant at 10% while UNEMP is not significant at 10% or less. This model aligns to Mateko (2024) and David (2023).

The VECM empirical model

$$\Delta POVT_{it} = 85.68 + 0.14\Delta ICT_{it-1} + 1.1\Delta EG_{it-1} - 1.7\Delta HD_{it-1} + -0.02\Delta INC_{it-1} + 1.04\Delta INEQ_{it-1} - 2.69\Delta UNEMP_{it-1} + \varepsilon_{it}$$

Impulse response

The measurement of the unit shock imparted to each series, as well as its overall impact on the VAR system, can be done using impulse response (David, 2017). In this study, impulse response analysis was employed to gauge how endogenous variables in the VAR model reacted. The VAR model's responses to standard deviation are depicted in the figures below.

The response of POVT to ICT innovation impulse showed that in the period 1-4, the figure shows a decrease in ICT innovation and that the variable shows a negative trend but without any fluctuations. This indicates that POVT reacted negatively to a single standard innovation shock, both in the short term and long term. In simpler terms, when there was a push or change introduced through ICT innovation, POVT's performance or results were declined consistently over time, showing no signs of recovery or improvement during this period, as aligned to Chang et al (2022).

The response of ICT to POVT innovation impulse showed that in the period 1-4, the figure shows a decrease in ICT innovation and that the variable shows a negative trend but without any fluctuations. This shows a negative response to one standard shock of innovation given to POVT both in the short-run and the long-run period. In other words, when POVT implemented an innovation, it led to a consistent decline in ICT performance over this time frame.

Variance decomposition

The variance decomposition was carried out using the impulse response analysis of the unrestricted VAR estimation process and the orthogonalised Cholesky ordering technique. This was done for the variables below: poverty, ICT, economic growth, human development, income, inequality and unemployment. Period 1 is assumed to be the short-run period while period 4 is assumed to be the long-run period.

Table 7: Variance decomposition: poverty

Period	S.E.	POVT	ICT	EG	HD	INC	INEQ	UNEMP
1	0.705802	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	1.181809	93.36325	3.874980	0.409316	0.334274	1.867270	0.140889	0.010022
3	1.650751	87.05661	4.758151	0.211580	0.241456	7.492583	0.081154	0.158468
4	2.061242	82.61788	4.660436	0.142432	0.160550	12.11072	0.056923	0.251054

Source: Researcher's construct (2023)

Table 7 shows that in the short run, shocks to poverty account for 100% variation of the fluctuation in poverty, while in the long-run it accounts for 82.62%. In the short run, shocks to ICT account for 0.00% variation of the fluctuation in poverty while in the long run it accounts for 4.66%. In the short run, shocks to economic growth account for 0.00 % variation of the fluctuation in poverty, while in the long run it accounts for 0.14%. In the short run, shocks to human development account for 0.00% variation of the fluctuation in poverty while in the long run it accounts for 0.16%. In the short run, shocks to income account for

0.00% variation of the fluctuation in poverty while in the long run it accounts for 0.16%. In the short run, shocks to inequality account for 0.00% variation of the fluctuation in poverty while in the long run its accounts for 0.05%. In the short run, shocks to unemployment account for 0.00% variation of the fluctuation in poverty while in the long run it accounts for 0.25%.

Information and communication technology (ICT)

Table 8: Variance decomposition of ICT

Period	S.E.	POVT	ICT	EG	HD	INC	INEQ	UNEMP
1	4.591275	5.029364	94.97064	0.000000	0.000000	0.000000	0.000000	0.000000
2	7.369523	9.076104	81.47909	5.639825	0.128689	1.544377	1.640308	0.491609
3	9.240887	10.95034	78.56699	4.519904	0.286122	2.304968	2.941356	0.430317
4	10.80401	11.79346	75.73352	4.410074	0.236683	2.987414	4.459010	0.379836

Source: Author's calculation (2023)

Table 4 shows that in the short run, shocks to poverty account for 5.03% variation of the fluctuation in ICT while in the long-run it accounts for 82.62%. In the short run, shocks to ICT account for 94.97% variation of the fluctuation in ICT while in the long run it accounts for 75.73%. In the short run, shocks to economic growth account for 0.00 % variation of the fluctuation in ICT while in the long run it accounts for 4.41%. In the short run, shocks to human development account for 0.00% variation of the fluctuation in ICT while in the long run it accounts for 0.24%. In the short run, shocks to income account for 0.00% variation of the fluctuation in ICT while in the long run it accounts for 2.99%. In the short run, shocks to inequality account for 0.00% variation of the fluctuation in ICT while in the long run its accounts for 4.46%. In the short run, shocks to unemployment account for 0.00% variation of the fluctuation in ICT while in the long run it accounts for 0.37%.

Post estimation results

The post-estimation tests carried out produced results, which had all eagen values less than 1, meaning that the VEC model is stable. The post estimation tests carried out also included Sargan test for indogeneity, Wald test for panel significance and Arellano Bond tests for serial autocorrelation which all produced plausible results.

5. DISCUSSIONS AND CONCLUSIONS

This section discusses the conclusions from results obtained, aligning the objectives, results and hypothesis outcomes. The first objective of the research was to find out if there is a relationship between ICT and poverty in South Africa. Using the correlation coefficient analysis, the results showed that there was a relationship between ICT and poverty. The nature of relationship which was discovered was that, there is a negative relationship between ICT and poverty, meaning to say, an increase in ICT will result in a decrease in poverty, which is a plausible gesture. The strength of the relationship was found out to be moderate at 74%. These results agree with researchers done by Masango (2017) and Moodley (2005) who discovered that South African policies towards ICT were subdued and that caused poverty to increase in the form of less access to ICT (Masango, 2017) and less access to food (Moodley, 2005). These results regarding the relationship between ICT and poverty lead to the acceptance of the alternative hypothesis (H_1) of the first hypothesis, which states that there is a relationship between ICT and poverty in South Africa.

The second objective of the study was to determine the causal relationship between ICT and poverty in South Africa. A granger causality test was conducted for the data which had 30 observations from 1990 to 2020. The results clearly indicate that ICT Granger-causes poverty in South Africa, as the null hypothesis—which stated that ICT does not Granger-cause poverty—was correctly rejected. The results were produced on lag 2 and had a probability of 0.028 which was less than 0.05. This means that, surely ICT causes poverty, which is in line with other researchers who have explored and found out that South Africa's ICT policies are actually causing poverty.

In the third objective, there was quest to discover if there is long-run and short-run equilibrium between ICT and poverty in South Africa. To arrive at the decision, the researcher diagnostically tested for stationarity, selected the best lag and used co-integration to find out if there were any short run and long run equilibria. The results showed that data possessed only long run equilibrium whereby the presence of long-run relationships was pronounced since most of the tests were significant at least at 10% using the restricted VECM model. In this case, we accept H_1 (alternative hypothesis) which points out that, there is a long-run and short-run equilibrium between ICT and poverty in South Africa.

The last objective was to find out if there is a mutual feedback shock between ICT and poverty in South Africa. The results showed that, in the short run, shocks to poverty account for 100% variation of the fluctuation in poverty, while in the long-run it account for 82.62%. But on the other side, in the short run, shocks

to poverty account for 5.03% variation of the fluctuation in ICT while in the long-run it accounts for 82.62%. Indeed, there are some mutual feedback shocks between ICT and poverty, though the feedback shocks from ICT to poverty were more than feedback shocks from poverty to ICT. In this regard, we accept H_1 (alternative hypothesis) which stipulates that there is a mutual feedback shock between ICT and in South Africa.

The following are the recommendations emanating from results obtained:

- It is recommended that the South African Government must increase the portion of national budget attributable to ICT. The increase in public expenditure in ICT will result in capacitation of entities receiving the investment so that systems, hardware and software, ICT skills development and engagement of all the ICT related aspects can be bankrolled and effectively produced. However, evaluation and monitoring mechanisms must be established to ensure that the outcomes of such efforts can be properly assessed and made visible.
- The researcher recommends that friendly and flexible ICT policies much be prioritised from national government level down to local councils and households, and that inclusion criterion of the ICT policies should simply include everyone. By friendly policy the researcher means that that the goal and response characteristics of the policy must be approachable to the ever-changing business environment, as opposed to being hegemonic and rigid, as previously noted by Masango et al. (2017) and Akinboade et al. (2022)
- The Government of South Africa is recommended to provide affordable ICT gadgets such as cellphones, computers, affordable mobile subscriptions and internet subscription. Affordability is explained by prices which the poor to middle income earners can manage to pay for the ICT gadgets. This entails the government putting subsidies towards the prices of the GPTs in ICT. When the ICT user is incapacitated, then access and use are compromised.
- It is recommended that ICT subject/module be a compulsory subject/module in all educational spheres, from preschool up to tertiary, from a training seminar to a symposium, from a conference to a roadshow. The focus objectives should be on contemporary ICT skills such as programming, digitalisation, online business and disruptive technologies (crypto-markets, social media, e-business etc.), over and above the simple knowledge of knowing Microsoft packages. The emphasis should be on ICT for productivity, rather than on the mere acquisition of ICT gadgets

and perceived entitlement, which many economic agents ultimately use as a basis for comparing idle forms of wealth (symbols/toys of wealth).

- Inclusive ICT provision is recommended. A significant proportion of the South African population consists of dependents, including young children (under the age of 10), the elderly (over the age of 65), and persons living with disabilities. It is encouraged that specialised ICT devices—both hardware and software—be made affordably available. These may include televisions, radios, assistive response systems, and speech-enabled devices to support individuals with physical and cognitive impairments.
- Digital inclusion should be enhanced across all business entities—whether in the private sector, public sector, or semi-public/private organisations. ICT knowledge is a valuable asset; however, the effective and inclusive use of ICT is essential so that its benefits can contribute to reducing poverty in all its forms.
- The government should liberalise the industry for both Mobile Network Operators (MNOs) and Virtual Mobile Network Operators (VMNOs), in order to increase the availability of mobile networks, foster competition, and thereby improve affordability.
- Digital poverty should be treated as a priority, especially considering that the UNDP has identified education, health, and standard of living (income) as the three core dimensions of poverty. The premise is that, with the advent of the Fourth Industrial Revolution, failure to define, recognise, and explain digital poverty will result in the digitally excluded remaining within the poverty bracket. Government policies on ICT must be grounded in a comprehensive understanding of ICT—its impact, effects, causality, and implications for poverty.

Conflict of interests

Authors declare there is no conflict of interest.

REFERENCES

Akinboade, O.A., Ziramba, E. & Kinfack, E.C., (2022). *ICTs and poverty reduction in South Africa: Evidence from time-series analysis. Journal of African Development, 24*(1), 1–22.

Bennet, M., Kallus, N. & Schnabel, T., (2019). *Data-driven estimation of inverse covariance matrices for high-dimensional VAR models. Journal of Econometrics, 212*(1),144–163.

Caceres, L.R., (2007). *The impact of ICT on economic growth in developing countries. International Economic Journal, 21*(2), 219–239.

Chang, J., Lee, M. & Park, Y., (2022). *The dynamic interaction between ICT and poverty: A VAR approach. Journal of Development Studies, 58*(6), 789–807.

David, B., (2017). *Impulse response analysis in vector autoregressive models. Econometrics Journal, 20*(2), 112–125.

David, B., (2023). *Short-run and long-run dynamics of ICT and economic indicators in emerging economies. African Economic Review, 35*(3), 203–221.

David, O.O., (2019). *Information and communication technology and economic growth in Africa. Telecommunications Policy, 43*(7), 1019–1028.

Dickey, D.A. & Fuller, W.A., (1979). *Distribution of the Estimators for Autoregressive Time Series with a Unit Root. Journal of the American Statistical Association, 74*(366), 427–431. https://doi.org/10.2307/2286348

Erum, N. & Hussain, S., (2019). *Corruption, market size and ICT in OIC countries: A panel data analysis. Journal of Economic Studies, 46*(5), 1037–1054. https://doi.org/10.1016/j.resourpol.2019.101429

Fernandez-Portillo, A., Almodovar-Gonzalez, M., Diaz-Casero, J.C. & Sánchez-Escobedo, M.C., (2019). *Impact of ICT on competitiveness, innovation and environment in SMEs: A systematic review. Sustainability, 11*(21), 1–20.

Gujarati, D.N., (2022). *Econometrics by Example*. 4th ed. Palgrave Macmillan.

Howard, J. & Horn, A., (2014). *The impact of ICTs on poverty in Africa: A review of current literature. African Journal of Information and Communication, 14*(1), 40–56.

Ishida, H., (2015). *The effect of ICT development on economic growth and energy consumption in Japan. Telematics and Informatics, 32*(1), 79–88. https://doi.org/10.1016/j.tele.2014.04.003

Landau, R. & Rosenberg, N., (1986). *The positive sum strategy: Harnessing technology for economic growth*. Washington, DC: National Academy Press.

Masango, C., (2017). *Challenges in the implementation of ICT policy in South Africa. Journal of African Media Studies, 9*(2), 243–257.

Masango, C., Van Ryneveld, H. & Graham, M., (2017). *Challenges in the implementation of ICT policy in South Africa: Perspectives from the SMME sector. South African Journal of Information Management, 19*(1), 1–9.

Masango, C., Van Ryneveld, H. & Graham, M., (2022). *ICT for development in Southern Africa: Challenges and policy frameworks*. *Development Southern Africa, 39*(4), 571–586.

Mateko, B., (2024). *The Relationship Between ICT and Poverty in Developing Economies: A South African Perspective*. University of South Africa Press, Pretoria.

May, J., (2012). *ICT access and usage in poor rural communities: Findings from surveys in South Africa*. Information Technologies & International Development, 8(2), pp.1–14.

Moodley, S., (2005). *The promise of information and communication technology for reducing poverty in South Africa. Development Southern Africa, 22*(2), 229–244.

Olamide, A.O., Kazeem, B.A., Mbatha, T. & Ndlela, L.L., (2022). *Information and Communication Technologies and sustainable development in Southern Africa.* African Journal of Economic Policy, 29(3), 119–140.

Raheem, I.D., Tiwari, A.K. & Balsalobre-Lorente, D., (2020). *ICT and income inequality: Evidence from emerging economies. Telecommunications Policy, 44*(5), 1–13.

Romer, P.M., (1986). *Increasing returns and long-run growth. Journal of Political Economy, 94*(5), 1002–1037. https://doi.org/10.1086/261420
Saidi, K. & Mongi, C., (2018). *Effect of ICT on economic growth and environment in African countries. Telecommunications Policy, 42*(7), 513–522.
Schumpeter, J.A., (1928). *The instability of capitalism. The Economic Journal, 38*(151), 361–386. https://doi.org/10.2307/2224315
Seleteng, M., (2016). *Investigating the Causal Relationship Between ICT and Poverty in Southern Africa: A Time Series Approach. African Development Review, 28*(3), 312–324.
Spiezia, V., (2013). *ICT investments and productivity: Measuring the contribution of ICTs to growth. OECD Journal: Economic Studies, 2013*(1), 1–19. https://doi.org/10.1787/eco_studies-v2012-1-en.
StatsSA, (2022a). *Poverty trends in South Africa: An examination of absolute poverty between 2006 and 2020*. Statistics South Africa, Pretoria.
Thabo, M., (2003). *The dark side of ICTs in Africa: A critique on access and affordability. Journal of African Development, 6*(2), 55–70.
Tripathi, N., (2011). *Econometric Models and Techniques*. Discovery Publishing House, New Delhi.
World Bank, (2020). *Poverty and Shared Prosperity 2020: Reversals of Fortune*. World Bank Group. Washington, DC.
World Development Indicators, (2022). *World Development Indicators Database*. The World Bank. Washington, DC. https://databank.worldbank.org/source/world-development-indicators
Yucel, E., (2022). *Cointegration Analysis and Error Correction Models: Theory and Practice*. Economics Research Institute Publications, Istanbul.

УЗАЈАМНИ ПОВРАТНИ ШОКОВИ ИЗМЕЂУ ИНФОРМАЦИОНИХ И КОМУНИКАЦИОНИХ ТЕХНОЛОГИЈА И СИРОМАШТВА У ЈУЖНОАФРИЧКОЈ РЕПУБЛИЦИ

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САЖЕТАК

Ова студија се бави сложеним односом између информационо-комуникационих технологија (ИКТ) и сиромаштва у Јужноафричкој Републици, те истражује међусобне повратне шокове који динамички обликују оба домена користећи податке из Свјетских индикатора развоја за период од 1990. до 2021. године. Користећи свеобухватни аналитички оквир, студија истражује како напредак у ИКТ-у, индекс рачунара, мобилних

телефона и интернета, утиче на стопе сиромаштва, изражене односом броја становника, на краћи и дужи рок, те обрнуто: како социо-економски услови повезани са сиромаштвом утичу на ИКТ. Тест корелације, Грејнџеров тест узрочности, тест коинтеграције и VAR/VECM модели коришћени су у настојању да се пронађу одговори на питања. Емпиријски резултати су показали да постоји веза, при чему ИКТ заиста узрокује сиромаштво у Јужној Африци. VAR/VECM је утврдио да постоји дугорочна веза између ИКТ-а и сиромаштва у Јужној Африци, на нивоу значајности од 10%, а декомпозиција варијансе је додатно потврдила неке значајне краткорочне повратне шокове између ИКТ-а и сиромаштва. Препоручује се да влада Јужноафричке Републике успостави квалитетне и инклузивне политике у области ИКТ-а, посебно према маргинализованим и сиромашним општинама у којима многа мала и средња предузећа покушавају да напредују. Препоручује се развој вјештина и повећање јавних издатака за ИКТ, као напори за искорјењивање сиромаштва путем ИКТ-а. Кроз емпиријску анализу откривена је сложена динамика која подвлачи ову међусобну повратну спрегу, бацајући свјетло на потенцијалне механизме за прекидање циклуса сиромаштва кроз стратешке ИКТ интервенције. Ово истраживање не само да доприноси академском дискурсу о технологији и развоју, већ пружа и практичне увиде креаторима политике и заинтересованим странама које траже одрживе стратегије за рјешавање изазова сиромаштва у Јужноафричкој Републици.

Кључне ријечи: *информационо-комуникациона технологија, сиромаштво, узрочност, метода корекције векторских грешака, декомпозиција варијансе.*