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Raising a new Generation of Leaders

# EXTRACTING THE PATTERN OF IMPORT AND EXPORT AMONG AFRICAN REGION

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# Presentation Outline.

- i. Introduction/background of study
- ii. Statement of problems
- iii. Aim and objectives
- iv. Definition of terms
- v. Literature review
- vi. Methodology
- vii. Result and discussion
- viii. Summary, Recommendation and Conclusion
- ix. References

# Introduction

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- As globalization continues to reshape the dynamics of international commerce, it is imperative to discern import and export patterns within Africa (**International Economics Theory and Policy Book, 2020**).
- These patterns not only reflect the continent's economic relationships with the rest of the world, but also provide valuable insights into its internal trade dynamics, regional integration efforts, and potential for sustainable growth.

# Introduction

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- Africa is known for its abundance of natural resources, cultural diversity, and economic potential, and it is currently at a pivotal point in its development trajectory (**Bakari and Mabrouki, 2017**).

# Statement of problems

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- Understanding how African countries conduct their trade presents a significant challenge due to the absence of comprehensive data. Despite their diverse economic strengths, there remains a significant gap in our knowledge regarding their trading practices.

# Aim & Objectives

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- Aim:

This study aim to extract import and export patterns in the African region.

## Objectives:

- To examine if there exist significant differences in the distributions of the import and export among African countries.
- To determine the exact groups whose distributions are different, through pairwise comparisons.
- Explore and categorize African countries into (clusters) based on shared trading behaviours.
- Provide valuable insights aimed at assisting policymakers in making informed decisions related to African trade dynamics.

# Definition of Terms

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- **1.5.1 Imports and Exports**

- Imports: Goods and services brought into a country from other nations. (Source: Investopedia - Imports:
- Exports: Goods and services produced in a country and sold to other countries. (Source: Investopedia - Exports:

- **1.5.2 Trade Balance**

- The difference between a country's exports and its imports over a specific period. A positive trade balance indicates a trade surplus (exports exceed imports), while a negative balance indicates a trade deficit (imports exceed exports). (Source: International Monetary Fund - Balance of Trade:

- **1.5.3 GDP (Gross Domestic Product)**

- The total monetary value of all final goods and services produced in a country within a specific time period (usually a year). (Source: The World Bank )



# Definition of Terms cont'd

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- **1.5.5 Balance of Payments (BOP)**

A comprehensive record of a country's economic transactions with the rest of the world over a specific period. It includes all trade in goods and services, financial transfers, and capital flows. (Source: International Monetary Fund)

- **1.5.6 Terms of Trade**

A measure of a country's export prices relative to its import prices. A rising terms of trade ratio indicates an improvement in a country's trading position, while a falling ratio suggests a decline. (Source: The World Bank).

- **1.5.7 Trade Barriers**

Government policies that restrict international trade. These can include tariffs (taxes on imports), quotas (limits on the quantity of imports), subsidies (financial support for domestic producers), and regulations. (Source: World Trade Organization)

# Definition of Terms cont'd

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- **1.5.8 Comparative Advantage**

A principle in economics that suggests a country should specialize in producing and exporting goods and services for which it has a relative advantage compared to other countries. This leads to increased efficiency and global trade. (Source: Khan Academy)

- **1.5.9 Globalization**

The growing interconnectedness between countries worldwide. This is driven by increased trade, investment flows, movement of labour, and cultural exchange. (Source: Council on Foreign Relations)

- **1.5.10 Trade Agreements**

Formal agreements between countries to promote international trade by reducing or eliminating trade barriers (tariffs, quotas, etc.) and establishing common trade rules. Examples include Free Trade Agreements (FTAs) and customs unions.

# Literature Review

Author(s)	Contribution to Extracting Import/Export Patterns	Methodology
(Bakari and Mabrouki, 2017)	Developed a modification of the Friedman test to identify significant changes in import/export patterns over time for multiple countries.	Friedman Test
(MacQueen, 1967)	Proposed a K-means clustering approach based on import/export partner similarity to identify trade blocs with resource-intensive economies.	K-means clustering
(Uzonwanne, 2015)	Utilized the Wilcoxon signed-rank test to compare pre- and post-diversification import/export patterns within a single country.	Wilcoxon Signed-Rank

# Methodology

## Materials

- Dataset
- The dataset was extracted from the “World Bank” database. The dataset offers thorough insights into the import and export operations of the nations in the African region.

Country Name	Country Code	Continent	Year	Import value (% of GDP)	Export value (% of GDP)	Region
Algeria	DZA	Africa	2000	20.78862591	42.06971772	North Africa
Algeria	DZA	Africa	2001	22.01685879	36.68930544	North Africa
Algeria	DZA	Africa	2002	25.62963474	35.50453671	North Africa
Algeria	DZA	Africa	2003	23.87594361	38.24882942	North Africa
Algeria	DZA	Africa	2004	25.64819794	40.0532239	North Africa
Algeria	DZA	Africa	2005	24.07340587	47.20519509	North Africa
Algeria	DZA	Africa	2006	21.91932588	48.81068655	North Africa
Algeria	DZA	Africa	2007	24.8699642	47.06816484	North Africa
Algeria	DZA	Africa	2008	28.71117516	47.973343	North Africa
Algeria	DZA	Africa	2009	35.95267869	35.37165186	North Africa
Algeria	DZA	Africa	2010	31.42211391	38.44454735	North Africa

*Table 1: Sample of Imports and exports data*



# Methodology

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## Materials

- Friedman test
- According to (**Zach Bobbit, 2020**), The Friedman Test is a non-parametric alternative to the Repeated Measures ANOVA.(Analysis of Variance)
- It is used to determine whether or not there is a statistically significant difference between the means of three or more groups in which the same subjects show up in each group.
- The null hypothesis  $H_0$ : There is no significant difference between the means of three or more groups in which the same subjects show up in each group.

# Methodology

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## Materials

- Wilcoxon rank-sum test
- sometimes referred to as the Mann-Whitney U test (Sullivan & Feinn, 2012).
- It evaluates whether there is a statistical difference between the two groups' distributions. The Wilcoxon rank-sum test is appropriate for evaluating non-normally distributed data as, in contrast to parametric tests, it does not presuppose normality in the data.
- The null hypothesis  $H_0$ : There is no statistical difference between the two groups distribution.

# Methodology

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## Materials

### K-means clustering

The K-means is a partitioning method that operates as follows:

- Initialization: Create an initial partition of the data into “k” clusters where “k” is a predefined number of clusters.
- Distance Calculation: For each object in the first cluster, calculate the Euclidean distances from the object to the centroids of all clusters.
- Reassignment: If an object is found to be closer to the centroid of another cluster than to the centroid of its current cluster, it is reassigned to the other cluster.
- Centroid Update: Recalculate the centroids of the affected clusters, since their compositions have changed due to the reassignment.
- Iteration: Repeat the distance calculation, reassignment, and centroid update steps until all objects are positioned in the cluster with the nearest centroid, achieving an optimal solution.

# Methodology

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- **Methods**

Data Preprocessing:

- **Data Transformation:** Converted wide-format Excel data to long-format for analysis and visualization.
- **Data Cleaning:**
  - Checked for blank rows: None found.
  - Identified and dealt with duplicates: No duplicates detected.
  - Addressed missing data:
    - Excluded countries missing more than 10 years of data.
    - Imputed missing values using Last Observation Carried Forward (LOCF) method.



# Methodology

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- Methods

Data Preprocessing:

- **Data Aggregation:**

- Number of African Countries: 44 countries remaining after filtering.

- Sorting Countries by Regions: Categorized countries into North, West, East, Central, and

Southern Africa based on predetermined lists.

# Methodology

- Methods

## Data Preprocessing:

```
# Load necessary libraries
library(readxl)
library(dplyr)
library(tidyr)
library(ggplot2)
# Read the Excel file
trade_data <- readxl::read_excel("C:/Users/stu/Desktop/Project/import and export of good and services - Copy.xlsx")
# Filter African countries
african_countries <- c("Algeria", "Angola", "Benin", "Botswana", "Burkina Faso", "Burundi",
  "Cabo Verde", "Cameroon", "Central African Republic", "Chad", "Comoros",
  "Congo, Dem. Rep.", "Congo, Rep.", "Cote d'Ivoire", "Djibouti", "Egypt",
  "Equatorial Guinea", "Eritrea", "Eswatini", "Ethiopia", "Gabon", "Gambia",
  "Ghana", "Guinea", "Guinea-Bissau", "Kenya", "Lesotho", "Liberia", "Libya",
  "Madagascar", "Malawi", "Mali", "Mauritania", "Mauritius", "Morocco",
  "Mozambique", "Namibia", "Niger", "Nigeria", "Rwanda", "Sao Tome and Principe",
  "Senegal", "Seychelles", "Sierra Leone", "Somalia", "South Africa",
  "South Sudan", "Sudan", "Tanzania", "Togo", "Tunisia", "Uganda", "Zambia",
  "Zimbabwe")

african_trade_data <- trade_data %>%
  filter(`Country Name` %in% african_countries)
# Reshape the data into a tidy format using gather or pivot_longer function
tidy_african_trade_data <- african_trade_data %>%
  pivot_longer(cols = starts_with("20"),
    names_to = "Year",
    values_to = "Value")
# Now 'tidy_african_trade_data' contains the dataset in a tidy format
View(tidy_african_trade_data)
# Check for duplicates
duplicates <- tidy_african_trade_data[duplicated(tidy_african_trade_data), ]
# Print the duplicates (if any)
if (nrow(duplicates) > 0) {
  print(duplicates)
} else {
```

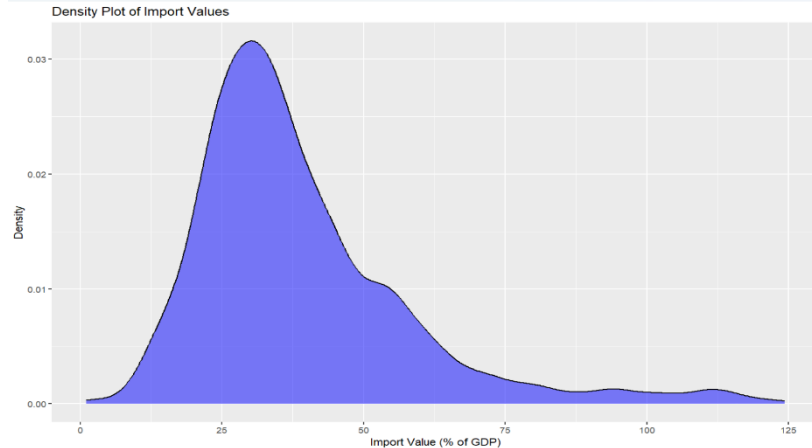
*Figure 1. A snippet of R code used for data preprocessing*

# Methodology

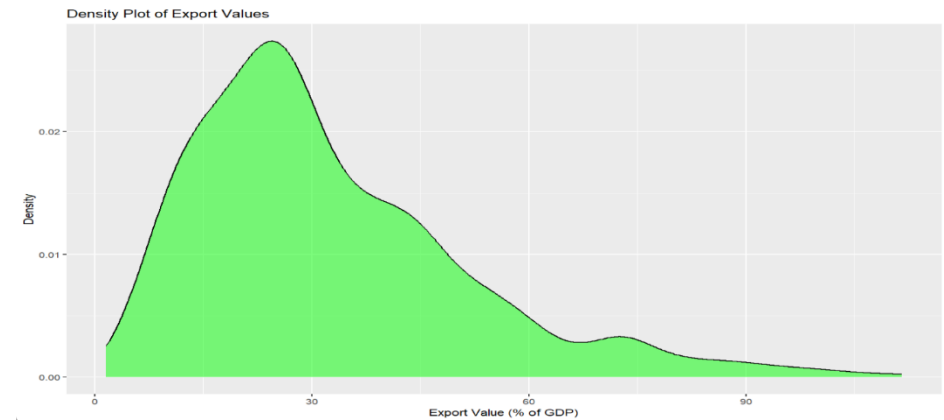
- Methods

## Normality/Skewness Tests on the import and exports Experimental Datasets

To determine if the import and export data follow a specific distribution, such as a normal, skewed, or non-parametric distribution, two strategies were used. For both the import value (% of GDP) and the export value (% of GDP), density maps were displayed separately.



*Figure 2 Density plot of imports across Africa*



*Figure 3 Density plot of Exports across Africa*

# Methodology

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- Methods
- **Normality/Skewness Tests on the import and exports dataset**
- To further prove the non-normality of the import and export data. The Shapiro Wilk's test was used and the result was as follows
- The null hypothesis of the Shapiro-Wilk test is that the data are normally distributed. A p-value less than the significance level (usually 0.05) indicates strong evidence against the null hypothesis.
- p-value for imports  $< 2.2 \times 10^{-16}$  (extremely small)
- p-value for exports  $< 2.2 \times 10^{-16}$  (extremely small)
- Based on the P values, we reject the null hypothesis and conclude that both the imports and exports data are not normally distributed.
- Hence we can use the non parametric tests to extract patterns in the import and export across Africa.



# Methodology

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- **Methods**

## **Experiment**

- **Dataset Verification:**

Non-parametric nature of the import and export dataset has been confirmed.

- **Testing Methods:**

Utilized non-parametric tests including Friedman, Kendall's W, and Wilcoxon rank sum tests to extract patterns in imports and exports across Africa.

Friedman Test Results for Import Data:

Friedman test statistic: 773.48

Degrees of freedom (df): 43

P-value:  $2.2 \times 10^{-16}$  Indicates statistically significant variations in import distributions.

# Methodology

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- Methods

## Experiment

- Friedman Test Results for Export Data:

Friedman test statistic: 842.06

Degrees of freedom (df): 43

P-value:  $2.2 \times 10^{-16}$  Reveals statistically significant variations in export distributions.

# Methodology

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## Methods

### **K-means Clustering**

- Normalization and Data Transformation:

- Prior to clustering, the raw import and export datasets were normalized to ensure uniform scaling.

- Countries within a cluster demonstrate similarity in their import and export levels.

- Result:

K-means clustering yielded three distinct clusters based on import and two distinct clusters based on export.

These clusters provide insights into the comparative import and export behaviors among countries.

# Methodology

- Methods

## K-means Clustering

Determining the optimal number of clusters

- The elbow method:

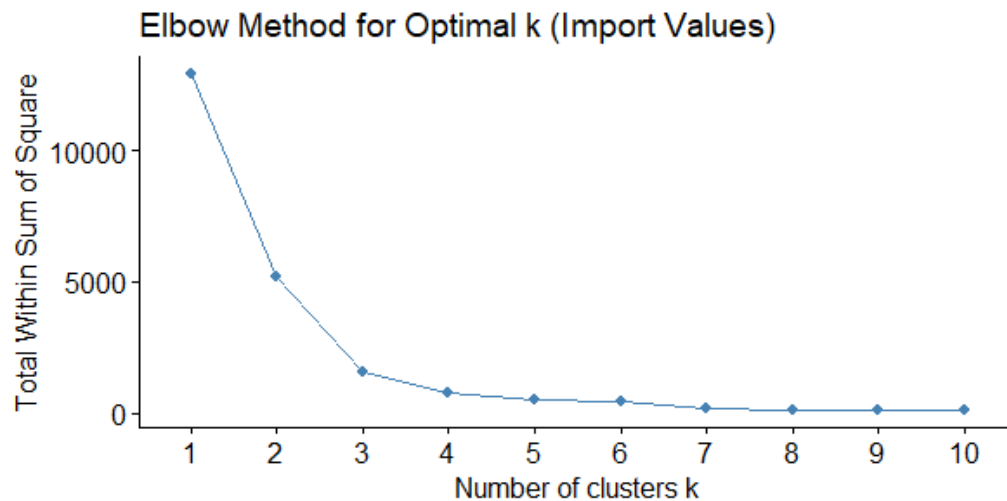


Figure 4: Elbow curve for optimal import K clusters

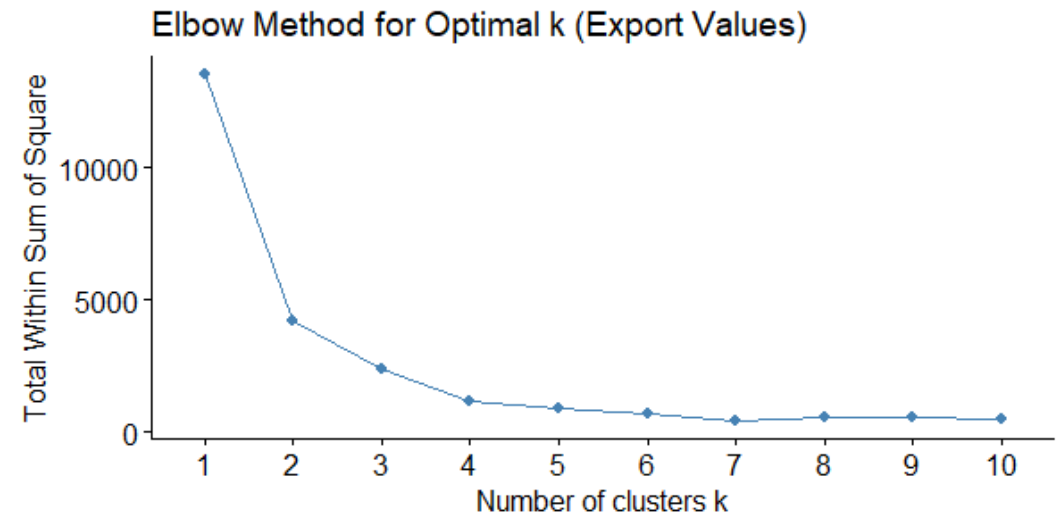


Figure 5: Elbow curve for optimal export K clusters



# Methodology

- Methods

## K-means Clustering

Determining the optimal number of clusters

- The Silhouette method:

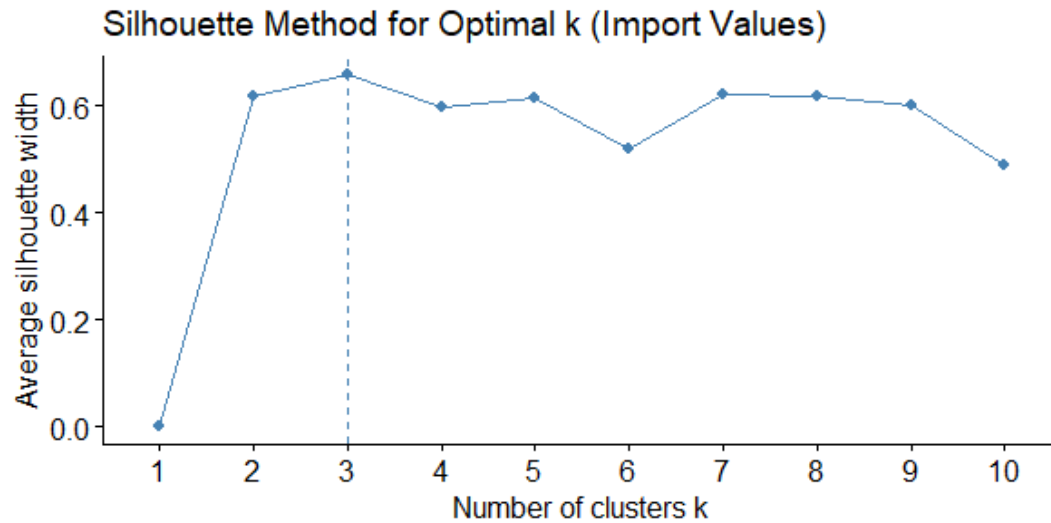


Figure 6: Silhouette curve for optimal import K clusters

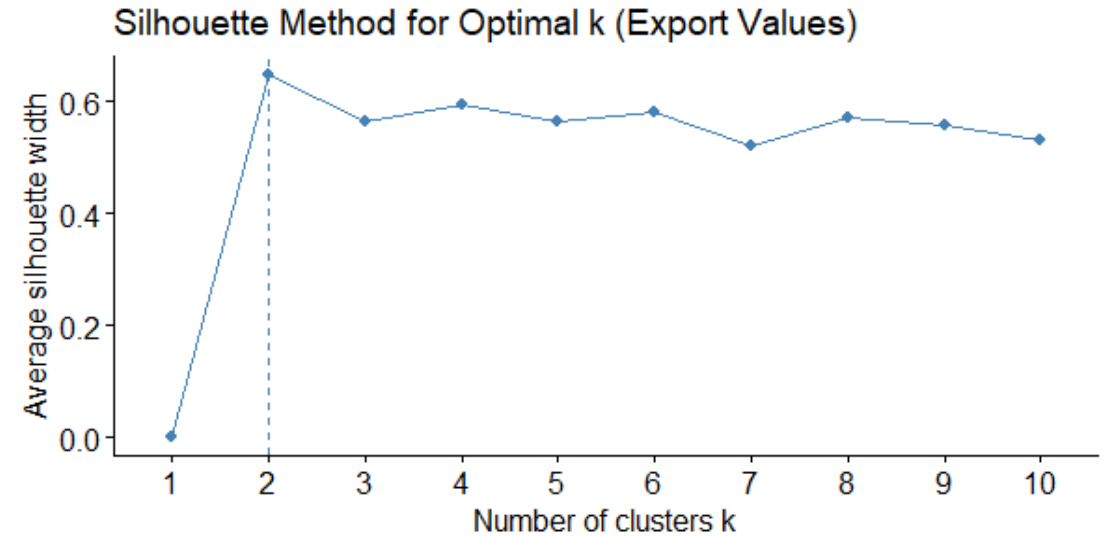


Figure 7: Silhouette curve for optimal export K clusters

# Methodology

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## Methods

- **K-means Clustering**

Cluster	No. of countries
1	13
2	2
3	29

*Table 2: Distribution of countries Import among clusters*

Cluster	No. of countries
1	32
2	12

*Table 3: Distribution of countries Export among clusters*

# Result and discussion

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- **Friedman Test**

Metric	Chi-Square statistic	DF	P-Value
Import (% of GDP)	773.48	43	$2.2 \times 10^{-16}$
Export (% of GDP)	842.06	43	$2.2 \times 10^{-16}$

- P values are less than 0.05
- indicates notable differences in the distribution of imports and exports among African countries.

# Result and discussion

## Pairwise Comparisons

- **Wilcoxon Rank-Sum Test Results:**
- Import Patterns: Highlighted pairs with insignificant differences (e.g., NIG & CMR, BEN & BFA)
- Export Patterns: Similar patterns identified (e.g., NIG & CHA, BWA & AGO)

	AGO	BDI	BEN	BFA	BWA	CAF	CIV	CMR	COD
BDI	<b>0.71462</b>								
BEN	<b>1.0000</b>	<b>1.0000</b>							
BFA	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>						
BWA	<b>1.0000</b>	5.60E-09	2.30E-10	5.10E-06					
CAF	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	5.00E-09				
CIV	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	3.90E-10	<b>1.0000</b>			
CMR	<b>0.41493</b>	<b>1.0000</b>	<b>0.28464</b>	<b>0.13459</b>	3.00E-10	<b>1.0000</b>	<b>1.0000</b>		
COD	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	0.03613	<b>1.0000</b>	<b>0.62588</b>	0.0072	
COG	<b>0.10787</b>	3.90E-10	2.30E-10	4.50E-06	<b>1.0000</b>	7.80E-10	2.30E-10	2.30E-10	0.00017
COM	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	3.90E-10	<b>1.0000</b>	<b>1.0000</b>	3.90E-05	<b>1.0000</b>
CPV	0.00349	2.30E-10	2.30E-10	4.50E-06	0.00643	2.30E-10	2.30E-10	2.30E-10	7.80E-10

Table 4: pairwise comparisons of Imports using Wilcoxon rank sum exact test

	AGO	BDI	BEN	BFA	BWA	CAF	CIV	CMR
BDI	4.00E-06							
BEN	6.30E-06	2.30E-10						
BFA	4.00E-06	2.90E-05	<b>1.0000</b>					
BWA	<b>1.0000</b>	2.30E-10	3.60E-10	4.00E-06				
CAF	4.00E-06	3.60E-10	1.60E-08	<b>1.0000</b>	2.30E-10			
CIV	0.00018	2.30E-10	0.00442	<b>0.05367</b>	7.60E-09	2.30E-10		
CMR	4.00E-06	2.30E-10	<b>1.0000</b>	<b>1.0000</b>	2.30E-10	5.60E-07	0.00012	
COD	0.00069	2.30E-10	<b>0.50692</b>	<b>0.36175</b>	4.40E-06	0.0001	<b>1.0000</b>	<b>0.19483</b>
COG	<b>0.65456</b>	2.30E-10	2.30E-10	4.00E-06	0.0001	2.30E-10	2.30E-10	2.30E-10

Table 5: pairwise comparisons of Exports using Wilcoxon rank sum exact test

# Result and discussion

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- **K-means Clustering – Imports**
- **Cluster 1:** Moderate import rates (e.g., Zimbabwe, Sudan)
- **Cluster 2:** High import rates (e.g., Cabo Verde (Cape Verde), Ghana)
- **Cluster 3:** Very high import rates (e.g., Seychelles, Lesotho)



# Result and discussion

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- **K-means Clustering – Exports**
- **Cluster 1:** Low to Moderate export rates (e.g., Mauritania, Burundi, Nigeria)
- **Cluster 2:** High export rates (e.g., Seychelles, Namibia)

# Result and discussion

- **K-means Clustering**

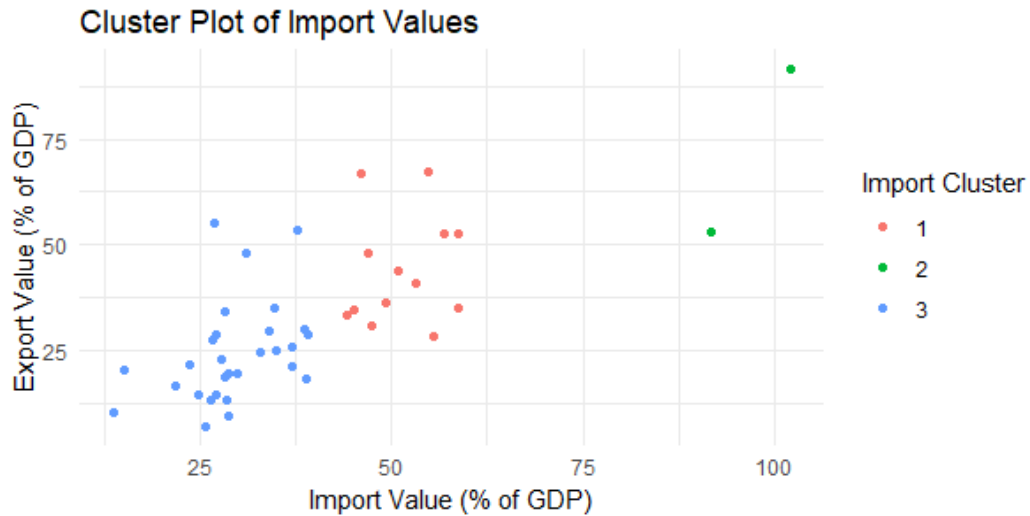


Figure 5: Cluster plot for Country import

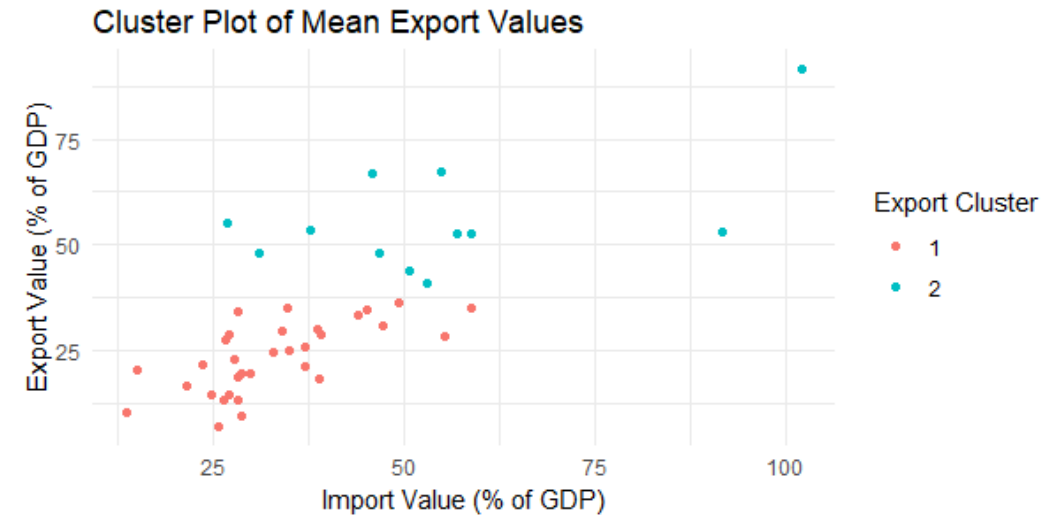


Figure 6: Cluster plot for Country Export

# Result and discussion

- **K-means Clustering**

Cluster	Max import (% of GDP)	Max import Country	Min Imports	Min Import Country	Number of countries
1	39.16463	Zimbabwe	13.60691	Sudan	29
2	58.7474	Cabo Verde	44.0595	Ghana	13
3	102.1028	Seychelles	91.65777	Lesotho	2

*Table 6: Cluster Summary for Country Import*

Cluster	Max import (% of GDP)	Max import Country	Min Imports	Min Import Country	Number of countries
1	36.40027	Mauritania	6.830969	Burundi	32
2	91.72947	Seychelles	40.95165	Namibia	12

*Table 7: Cluster Summary for Country Export*

# Result and discussion

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## Discussion

- Our analysis shows clear differences in trade patterns across Africa.
- For imports, we see that some regions have similar economic conditions or policies, forming interesting groups with common traits.
- When it comes to exports, some countries share the same markets or face similar external economic factors, indicating that they could work more closely together.
- These findings are crucial for developing trade strategies and policies that fit each country's unique economic situation.

# Summary, Recommendation and Conclusion

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- **Summary**
- **Significant Differences:** The Friedman test shows significant differences in import and export patterns among African countries.
- **Pairwise Comparisons:** The Wilcoxon rank-sum test highlights specific country pairs with similar or different trade patterns.
- **K means Clustering:** Countries are grouped into distinct clusters based on import and export activities, showing both similarities and differences.

# Summary, Recommendation and Conclusion

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- **Recommendation**

- **Targeted Trade Policies:** Design trade policies tailored to the specific needs and strengths of countries within each cluster.
- **Regional Collaboration:** Encourage regional collaboration within clusters to enhance trade efficiency and economic resilience.
- **Data-Driven Decision Making:** Use statistical analysis to inform effective trade and economic policies.



# Summary, Recommendation and Conclusion

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- **Conclusion**
- **Key Insights:** The study provides valuable insights into the import and export patterns of African countries, revealing significant variations and similarities.
- **Policy Implications:** Findings support the development of targeted trade policies and regional cooperation.
- **Future Research:** Future studies could expand the dataset, employ advanced statistical methods, and conduct case studies for deeper insights.

# References

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