

Strategic Predictive Modeling for Cargo Flow Forecasting and Ship Traffic Estimation in the Port of Mombasa

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Keywords: Mombasa Port, ARIMA, ARIMAX, LSTM, SARIMA, TEU, Ship Traffic,

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1. Introduction

1.1 Background

The global landscape of maritime trade has witnessed significant transformations, with seaports emerging as pivotal hubs facilitating the exchange of goods and fostering economic development. Within this context, the Port of Mombasa stands as a critical gateway, playing a central role in facilitating trade across East Africa. This research embarks on a comprehensive examination aimed at forecasting future traffic at the Port of Mombasa. The need for such a forecast is underscored by three primary objectives.

Firstly, a meticulous forecast serves as a strategic tool for port authorities to enhance cargo handling operations through the integration of advanced port infrastructure. The imperative to ensure efficiency within cargo handling operations not only optimizes port performance but also positions Mombasa Port as a preferred global destination for diverse cargo. The ensuing efficiency gains are expected to resonate on the international stage, thereby solidifying Mombasa Port's standing among the world's foremost ports.

Secondly, the Port of Mombasa, recognized as the largest port in East Africa, serves as a linchpin for at least five countries, including Uganda, Rwanda, Burundi, South Sudan, Tanzania, and the Democratic Republic of the Congo. The analysis of transshipment cargo and the formulation of forecasts for future cargo throughput to these hinterland

Citation: To be added by editorial staff during production.

Academic Editor: Firstname Last-name

Received: date

Revised: date

Accepted: date

Published: date



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countries constitute a critical aspect of this research. This endeavor is driven by the objective of empowering port authorities with insights to better plan for the dynamic trade demands emanating from these nations, fostering regional economic integration and ensuring the sustainable growth of the Port of Mombasa.

Lastly, against the backdrop of the Port of Mombasa's pivotal role, strategic port development plans are underway. The imminent construction and development of the Dongo Kundu port, slated to be the primary port in the Dongo Kundu Special Economic Zone, alongside the expansion projects at berths 23 and 25 of the Mombasa Container Terminal, herald a new era for the port's infrastructure. Considering these developments, the paper asserts the necessity to conduct a forecast of future cargo traffic, critically evaluating whether the ongoing and proposed capacity planning aligns efficiently with the anticipated demands. This assessment is paramount to ensure that the infrastructural expansions are not only visionary but also pragmatically aligned with the evolving needs of the maritime trade landscape.

In summary, this research endeavors to employ advanced forecasting methodologies to unravel the intricacies of future traffic at the Port of Mombasa, with the overarching goal of enhancing operational efficiency, fortifying regional trade ties, and scrutinizing the efficacy of ongoing and proposed port development plans. The significance of this research extends beyond the realm of maritime logistics, resonating with broader themes of economic development, international trade, and the sustainable growth of key regional players in the global trade network.

1.2 Literature Review

The introduction should briefly place the study in a broad context and highlight why it is important. It should define the purpose of the work and its significance. The current state of the research field should be carefully reviewed and key publications cited. Please highlight controversial and diverging hypotheses when necessary. Finally, briefly mention the main aim of the work and highlight the principal conclusions. As far as possible, please keep the introduction comprehensible to scientists outside your particular field of research. References should be numbered in order of appearance and indicated by a numeral or numerals in square brackets—e.g., [1] or [2,3], or [4–6]. See the end of the document for further details on references.

1.4 Mombasa Port Data Analysis

The **Figure** delineates the annual cargo throughput emanating from Mombasa Port, spanning the temporal interval of 2005 through 2022. The figure indicates a general increasing trend in cargo throughput over these years, suggesting a growth of activity in shipping in the Port of Mombasa.

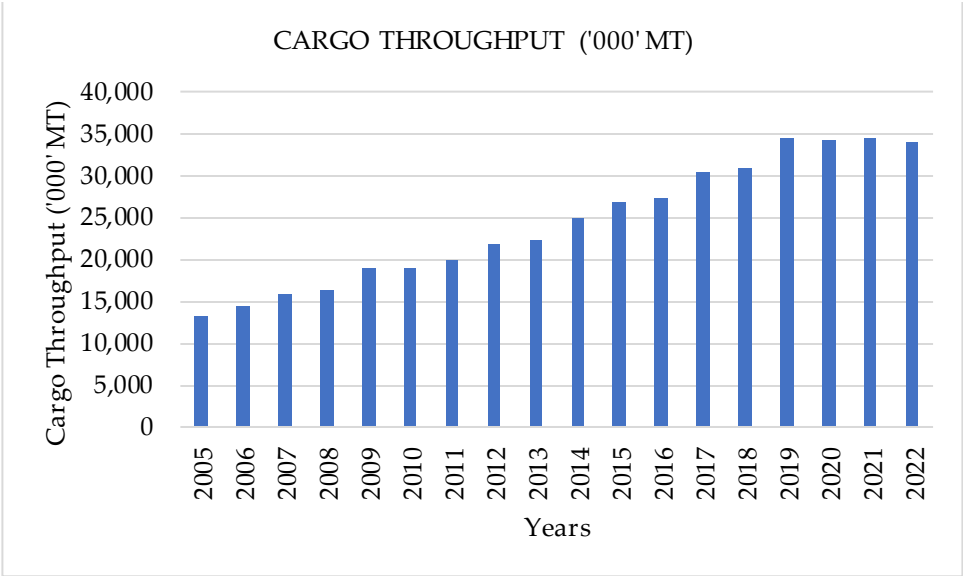


Figure: Total Cargo Throughput in Metric Tons between the Years 2005 to 2022
Source: KPA Statistics

Throughput based on imports and exports

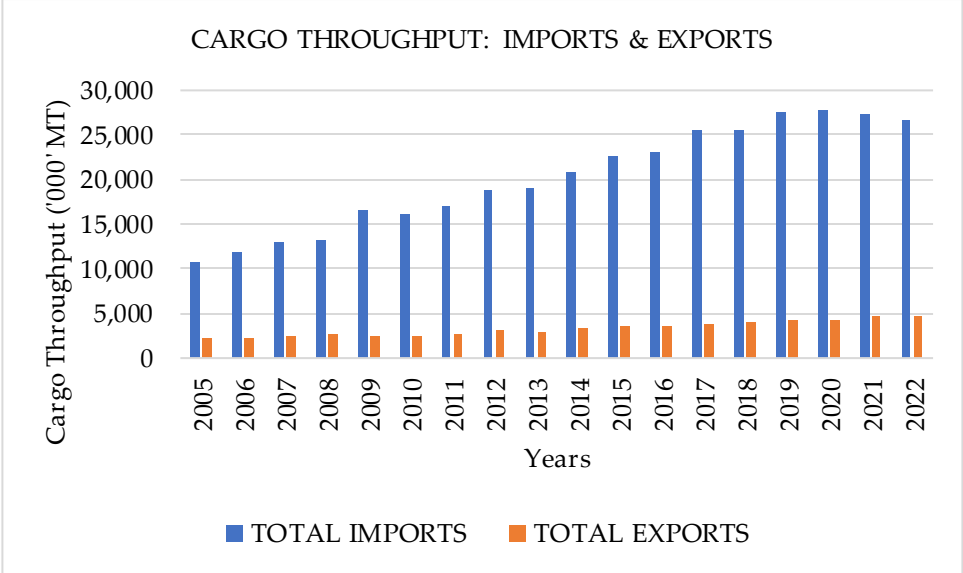


Figure: Cargo Throughput Distribution by Imports and Exports
Container Traffic Volume (TEU)

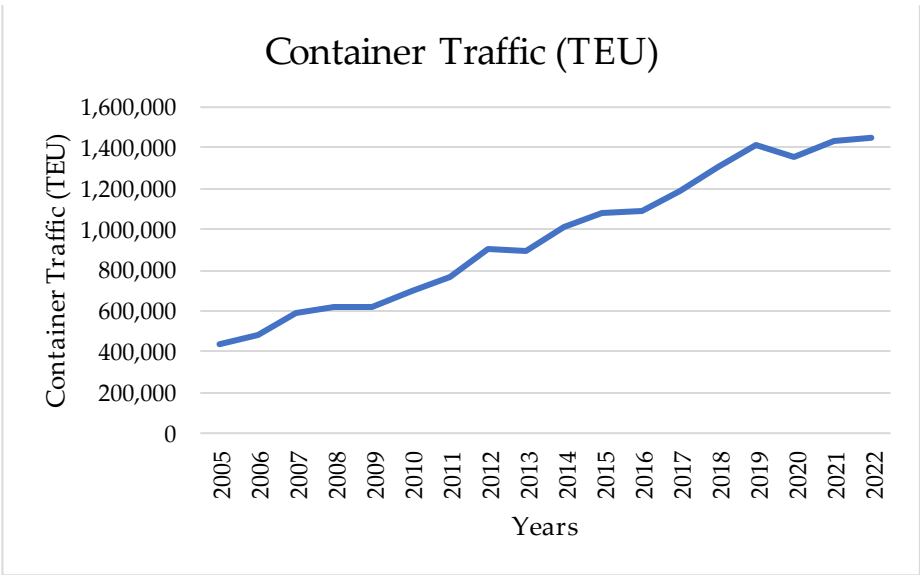


Figure:

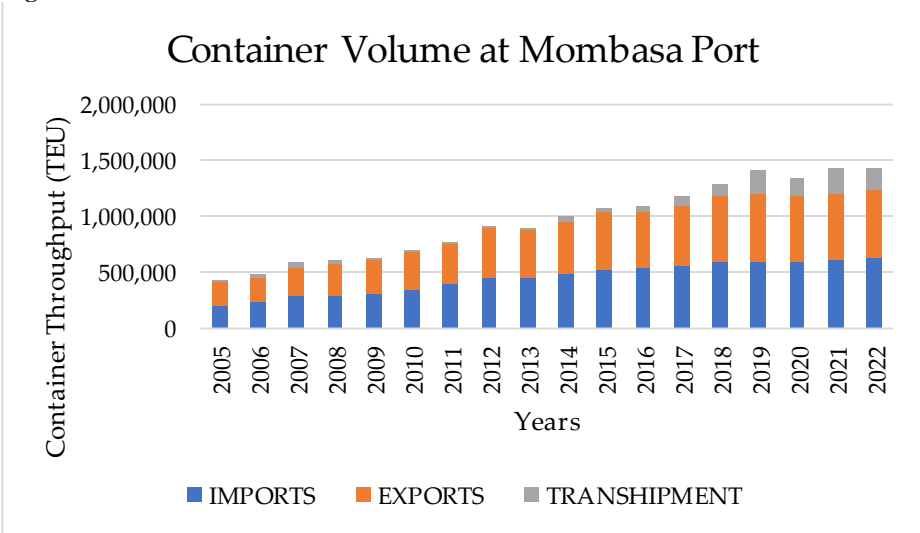
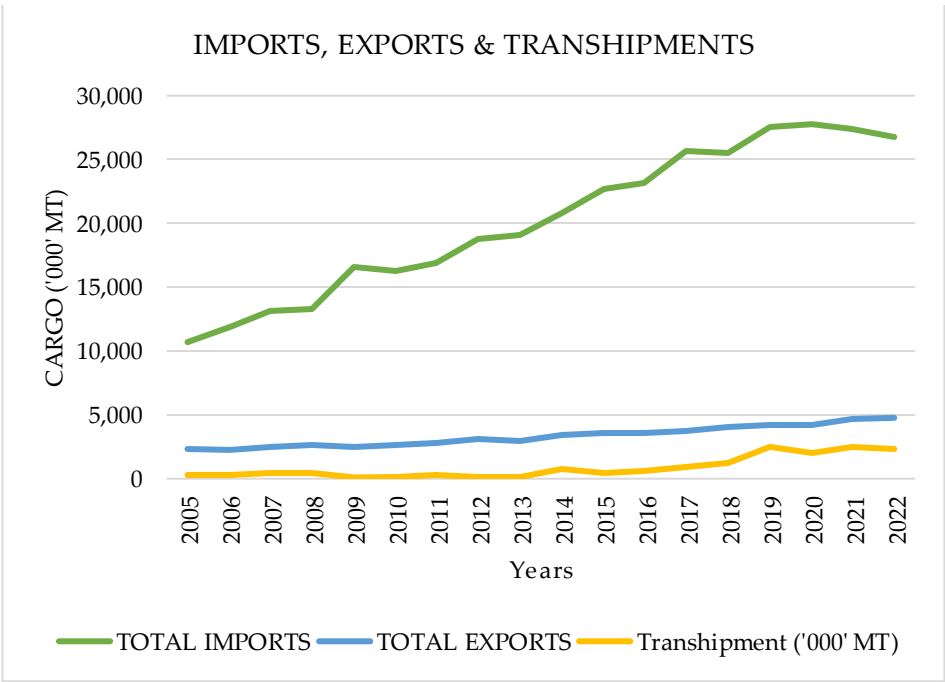


Figure:

The graph in Figure shows that both imports and exports have increased over the years, indicating a growth in trade and transportation. However, the graph also shows that every year, the total exports are higher than total imports, meaning that the country has a trade surplus.

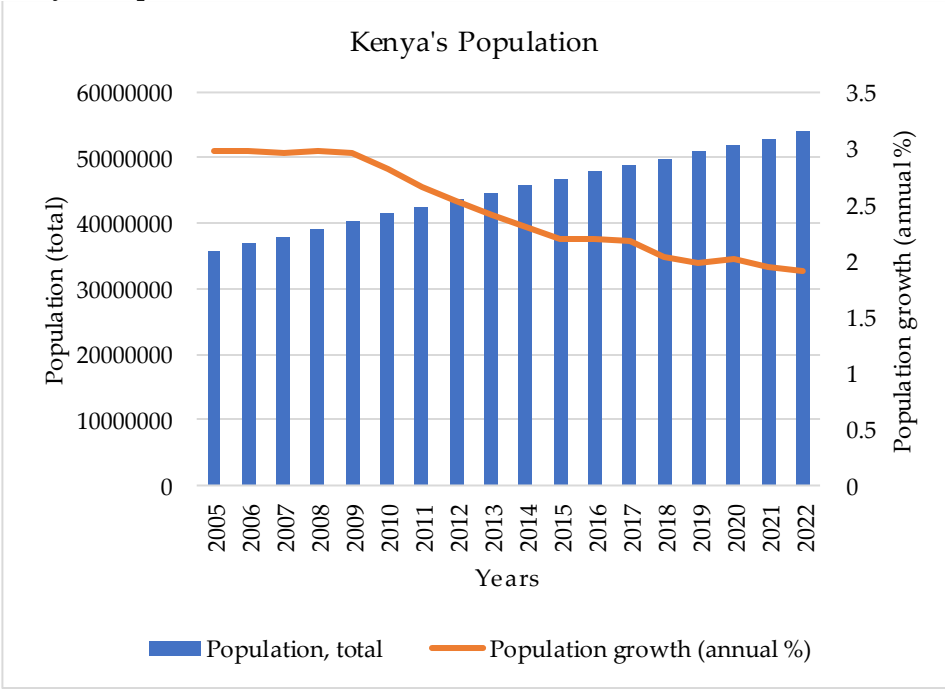
Throughput based on type of Cargo

Import volumes in the Port of Mombasa surpass both exports and transshipment volumes as illustrated in Figure. Export volumes remain relatively stable with time whereas the transshipment cargoes show a moderate increase over time. The key cargo types in the port for both exports, imports and transshipment cargo are containerized cargo, conventional cargo, dry bulk and liquid bulk.

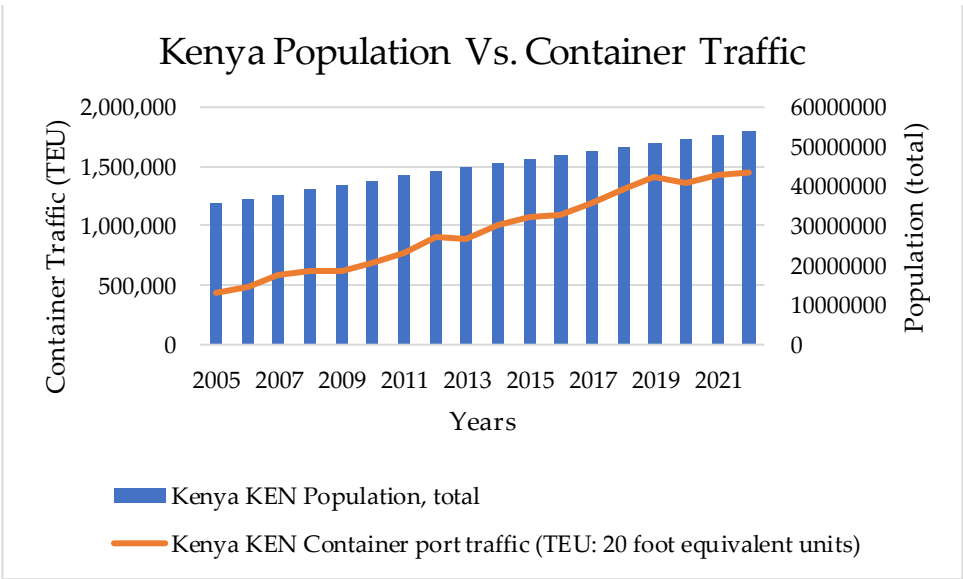


Economic Indicators

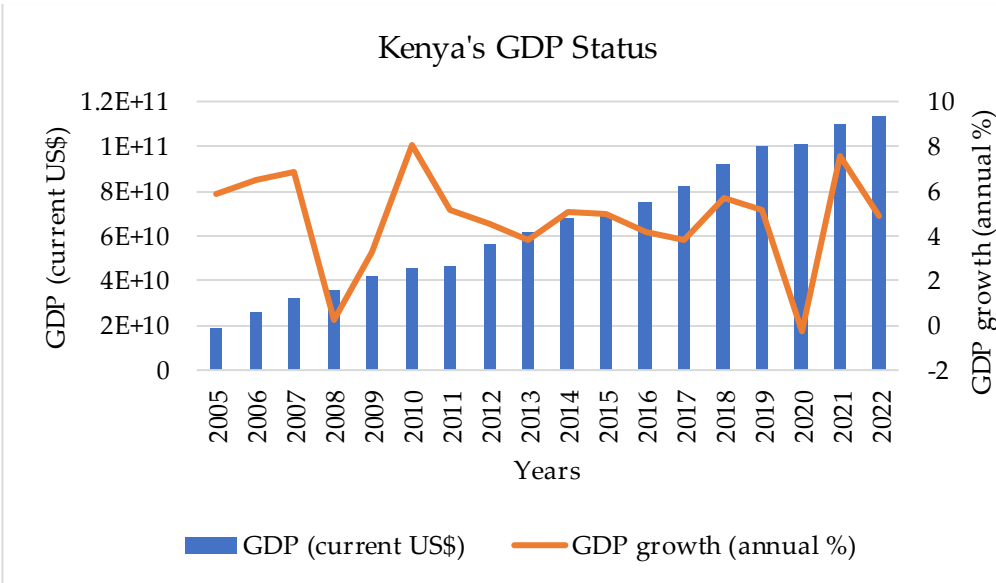
Kenya's Population



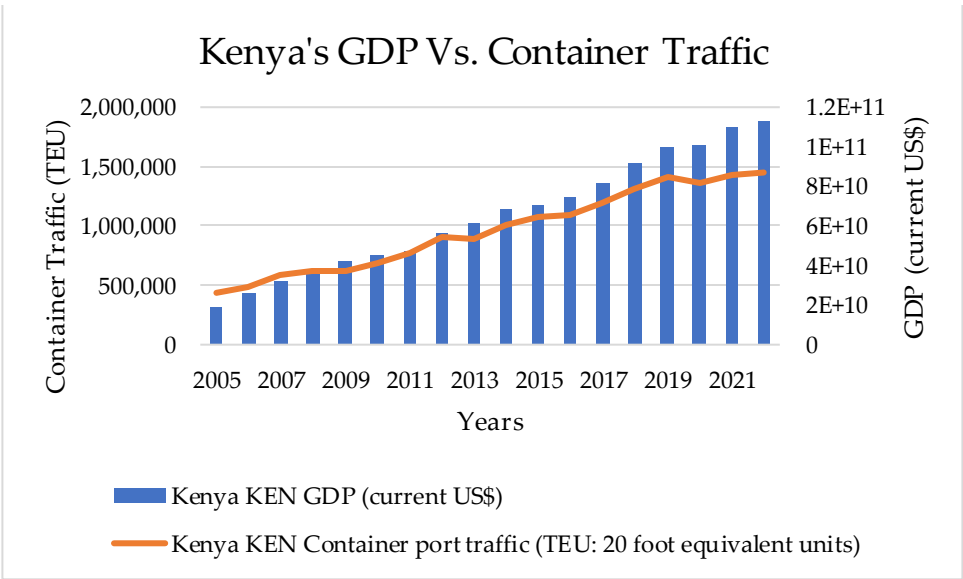
Kenya Population Compared to Container Traffic Growth



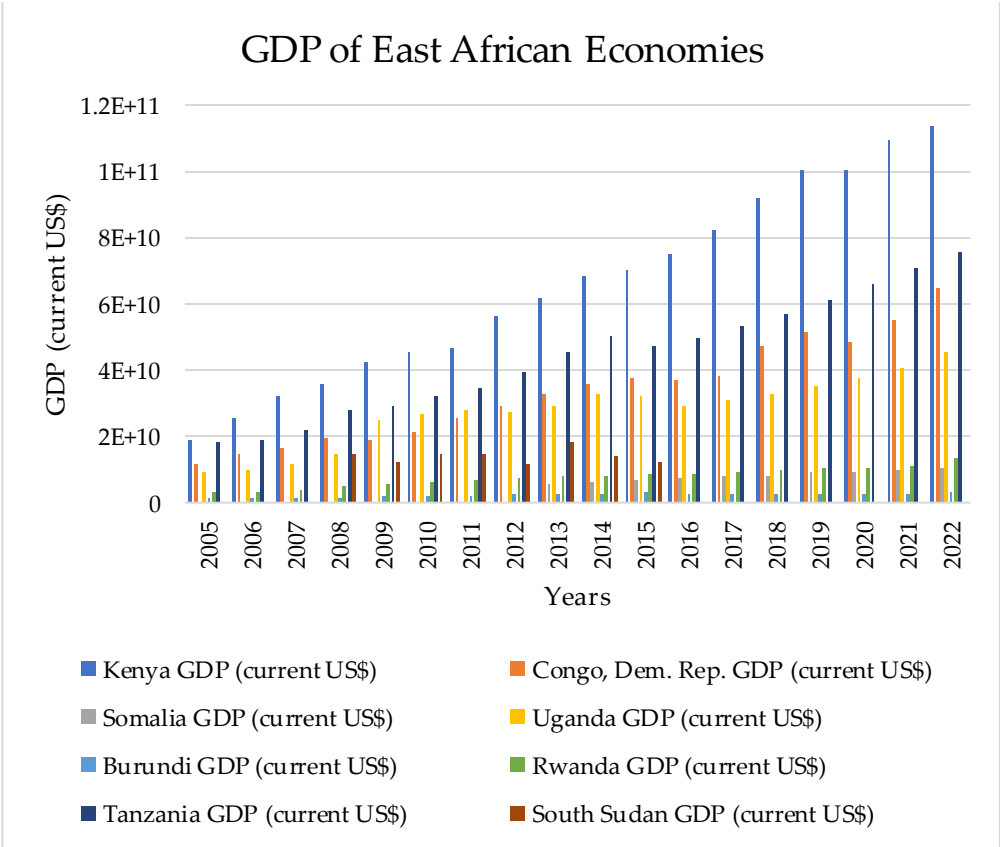
Kenya's GDP Status



Kenya's GDP Compared to Container Traffic Growth



East Africa Statistics



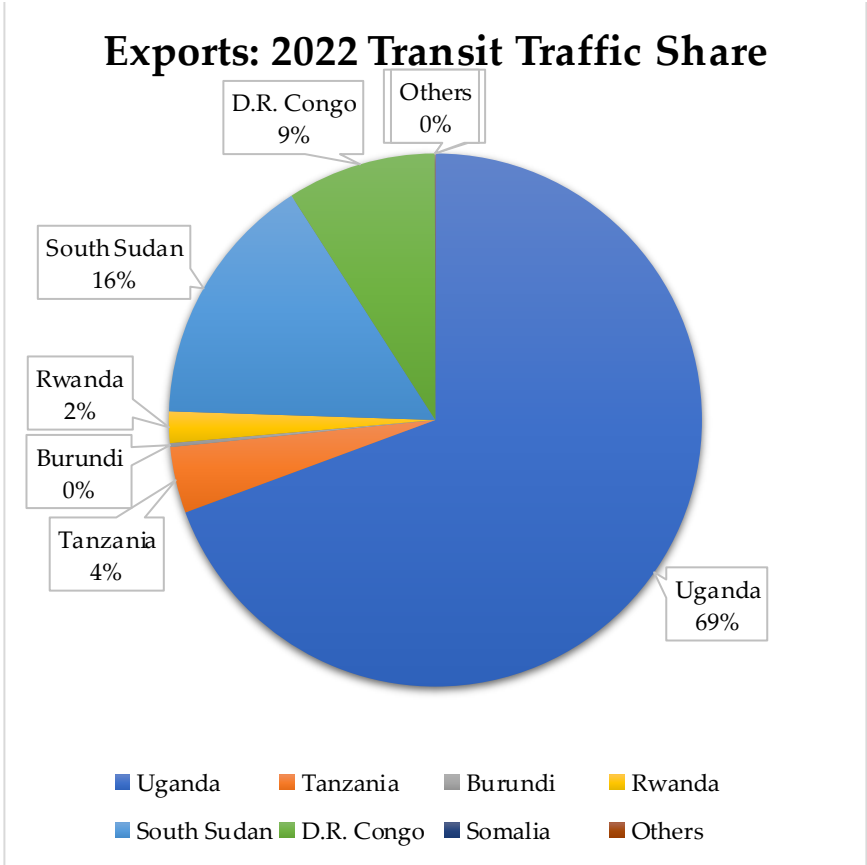


Figure:

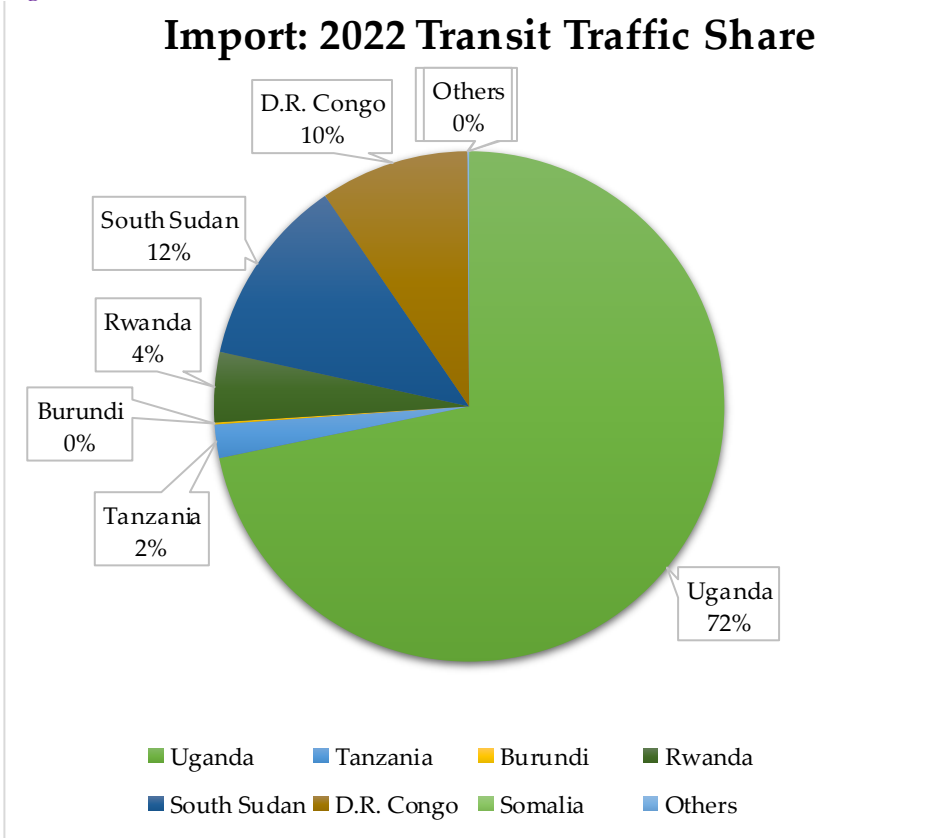


Figure:

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2. Materials and Methods

The Data Set

[Paraphrase later] The following table provides an overview of the variables with their measurement unit, the level of aggregation, the definition, the available periodicity and the source of data. The sample size for the empirical model is limited to 18 observations from 2005 to 2022.

Variable	Unit	Definition	Period	Source	
Container traffic (TEU)	TEU(Twenty Equivalent Units)		2005-2022	Kenya Ports Authority	Main variable
Population, total					Exogenous variable
GDP (Exogenous variable

Make a graphical representation of all variables (compare main variable with the two exogenous variables)

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3. Results

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

3.1. Subsection

3.1.1. Subsubsection

Bulleted lists look like this:

- First bullet;

- Second bullet;
 - Third bullet.

Numbered lists can be added as follows:

 1. First item;
 2. Second item;
 3. Third item.

The text continues here.
- 165
- 166
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3.2. Figures, Tables and Schemes

All figures and tables should be cited in the main text as Figure 1, Table 1, etc.

172

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Figure 1. This is a figure. Schemes follow the same formatting.

Table 1. This is a table. Tables should be placed in the main text near to the first time they are cited.

Title 1	Title 2	Title 3
entry 1	data	data
entry 2	data	data ¹

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The text continues here (Figure 2 and Table 2).

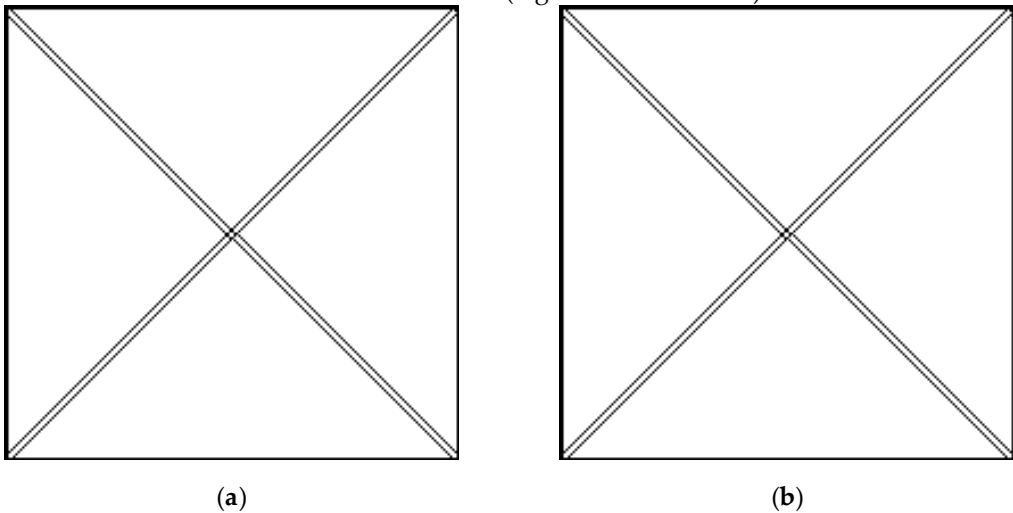


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Table 2. This is a table. Tables should be placed in the main text near to the first time they are cited.

Title 1	Title 2	Title 3	Title 4
entry 1 *	data	data	data

	data	data	data
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entry 2	data	data	data
	data	data	data
entry 3	data	data	data
	data	data	data
	data	data	data
entry 4	data	data	data
	data	data	data

* Tables may have a footer.

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3.3. Formatting of Mathematical Components

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This is example 1 of an equation:

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$$a = 1,$$

(1)

the text following an equation need not be a new paragraph. Please punctuate equations as regular text.

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This is example 2 of an equation:

189

$$a = b + c + d + e + f + g + h + i + j + k + l + m + n + o + p + q + r + s + t + u + v + w + x + y + z$$

(2)

the text following an equation need not be a new paragraph. Please punctuate equations as regular text.

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Theorem-type environments (including propositions, lemmas, corollaries etc.) can be formatted as follows:

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Theorem 1. *Example text of a theorem. Theorems, propositions, lemmas, etc. should be numbered sequentially (i.e., Proposition 2 follows Theorem 1). Examples or Remarks use the same formatting, but should be numbered separately, so a document may contain Theorem 1, Remark 1 and Example 1.*

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The text continues here. Proofs must be formatted as follows:

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Proof of Theorem 1. Text of the proof. Note that the phrase “of Theorem 1” is optional if it is clear which theorem is being referred to. Always finish a proof with the following symbol. □

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The text continues here.

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4. Discussion

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Authors should discuss the results and how they can be interpreted from the perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

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5. Conclusions

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This section is not mandatory but can be added to the manuscript if the discussion is unusually long or complex.

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to the main text—for example, explanations of experimental details that would disrupt 264
the flow of the main text but nonetheless remain crucial to understanding and reproduc- 265
ing the research shown; figures of replicates for experiments of which representative data 266

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