Acta Universitatis Danubius
ŒCONOMICA

Impact of Electricity Supply, Inflation and Exchange Rate Shocks on Import Flows in South Africa

Thomas Habanabakize[1], Mulatu Fekadu Zerihun[2]

Abstract: Import flows are one of the major economic variables that play a significant role in global trade and determine a country's economy's performance. The current article imperially scrutinizes the symmetric relationship between energy electricity supply, inflation rate, exchange rate and import flows in South Africa. This objective was achieved through the application of econometric models such as ARDL, ECM and T-Y approaches. These approaches were applied on monthly time series from January 2002 to October 2022. The results indicated the presence of long-run and short-run import flows behaviour electricity supply, inflation and exchange rate volatility. While the inflation rate and electricity supply positively influence long-run import flows, the latter is negatively influenced by exchange rate volatility. To improve import flows in South Africa, the study recommends policymakers' caution in selecting the country's adequate exchange rate regime and considering electricity supply and inflation rate while establishing the country's terms of trade.

Keywords: energy supply; exchange rate; inflation rate; import flows; trade; South Africa

JEL classification: E31; F14, F31, P48

1 Introduction

Global trade plays an important role in any country's economy as it allows the latter to expand its markets while having access to goods and services that are scares or unavailable within the domestic markets. In other words, international trade enables

[1] Tshwane University of Technology, South Africa, Address: Staatsartillerie Rd, Pretoria West, Pretoria, 0183, South Africa, Corresponding author: tomhaban15@gmail.com.
[2] Tshwane University of Technology, South Africa, Address: Staatsartillerie Rd, Pretoria West, Pretoria, 0183, South Africa, E-mail: Zerihunmf@tut.ac.za.

Copyright: © 2024 by the authors.
Open access publication under the terms and conditions of the
Creative Commons Attribution-NonCommercial (CC BY NC) license
(https://creativecommons.org/licenses/by-nc/4.0/)

countries to export their surplus products and import raw materials and scarce products (Tai 2022). These two components of trade, imports and exports, are significant in the South African economy as both can assist in improving the national economy and welfare. According to Edwards et al. (2017)'s findings, growth in South African imports leads to the country's exports which, in return, increases the country's production, wages and employment. On the other hand, export growth passively influences the country's economic growth and import flows more.

The significance of global trade in the south African economy is justified by, according to Stern and Ramkolowan (2021), the fact that the country intensely relies on exports to improve production and employment, and on import flows to satisfy consumer demand. Besides, as displayed in Figure 1, the share of the country's global imports and exports was equal in 2019 that is 0.4 percent for exports and 0.4 for imports (Stern & Ramkolowan 2021; Word Bank 2020).

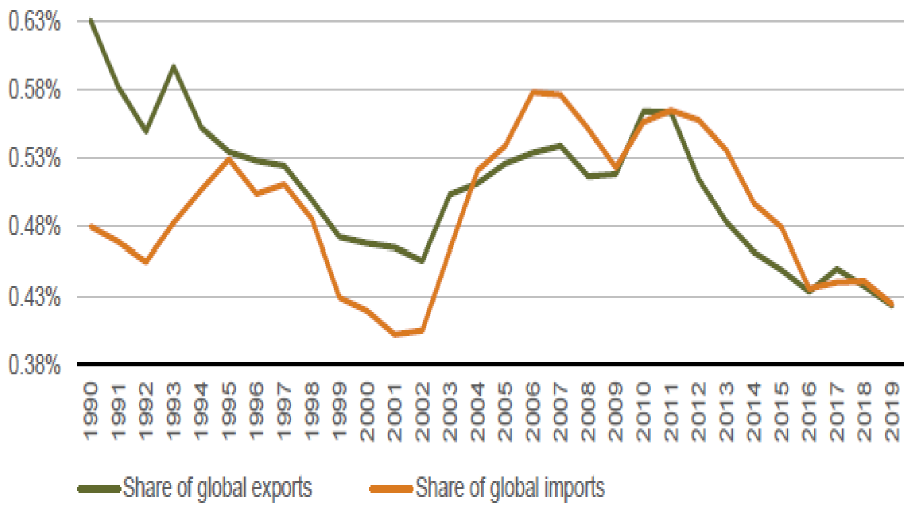


Figure 1. South African Share of Global Exports and Imports
Source: Word Bank, 2020.

Although both imports and exports are crucial to the country's economy, export growth is given more attention than import flows. In various periods several policies and programmes were introduced to enhance the country's export performance. Those programmes include the Integrated National Export Strategy initiated in 2015 and the National Development Plan (NDP) Vision 2030 introduced in 2017 (Edwards, 2020; Aye et al. 2015). Nevertheless, these programmes did not attain the expected results as the country keeps importing to satisfy consumer demand. This implies that the consideration of import flows is also necessary as exports and imports are like two sides of one coin and, therefore, they complement not substitute. They jointly improve the economy when they are well-managed.

Despite their role in the economy, exports and imports levels within a specific country are not independent. Shocks in other economic factors may also cause disturbances in export and import flows levels. For instance, the South African economy is currently facing challenges in electricity supply, inflation rate and exchange rate volatility which are key components of the country's economy's performance, and this might have implications for the country's aggregate import flows.

According to the South African reserve bank (SARB) (2021), South Africa relies heavily on import flows to satisfy its consumption demand. Additionally, inputs accessibility and export expansion are intensely influenced by import flows. This highlights the importance of import flows to the country and how its fluctuations might affect the country's economy. However, import flows are subjected to changes in various macroeconomic indicators which includes income per capita, population growth inflation rate, energy supply and exchange rate vitality among others. Several studies were conducted to investigate the determinant of economic indicators on exports in South Africa (Holden & Gouws, 1997; Onah et al., 2022; Rangasamy, 2009; Todani & Munyama, 2005) yet to the best knowledge of the other, few studies considered the importance of import flows and its determinants in South Africa. Consequently, the current study analyses the effect of these aforementioned economic variables on import flows in South Africa. This study provides answers to subsequent questions: why the South African economy has a positive balance trade while its currency is gradually duplicating? How do the inflation rate and electric supply impact import flow in South Africa? Does inflation cause import growth or vice-versa?

The maiming part of the study is structured as follows: Section two provides and discusses both theoretical and empirical literature. Section three discusses the study data, approach and methodology employed. Section four presents and discusses the study's empirical findings, while the last section provides a concise summary of the study, policy recommendations and opportunities for future research.

2. Literature Review

2.1. Inflation and Imports

Although inflation may have various definitions based on the source, Keynes (1936) describes inflation as an economic situation that occurs owing to an extreme desire of a group of people who want to capitalise on existing goods and services. Given that these people increase their demand while supply remains invariable, the excess demand causes a price rise. Therefore, inflation denotes an economic situation of the growing price of goods and services over a period of time. In simple terms, inflation means an increase in the price of a basket of goods and services in a given economy for a given period resulting from excess demand with a constant supply (Islam 2013). The presence of inflation causes wealth uncertainty and reduces people's purchasing power (Mankiw 2006) and consequently reducing economic growth and job growth. Various studies were conducted in different places to determine the relationship between inflation rate and import flows. A few of those studies and their findings are discussed in the subsequent paragraph.

A study conducted by Islam (2013) and Muktadir-Al-Mukit et al. (2015), in Bangladesh, suggested a positive relationship between inflation and import flows. The high inflation rate leads to a high demand for goods and services from the foreign market to Bangladesh's domestic markets. A positive impact of the inflation rate on import flows was also suggested by the stud of Ahmed et al. (2018) in Pakistan and the study of Okpe and Ikpesu (2021) in the Nigerian economy. Additionally, the study by Sahoo and Sethi (2018) suggests that high inflation in India caused an increase in money supply and demand for goods and services from abroad markets. Similar results were found by Abumdallala (2019).in the Palestinian economy and the author recommends a reduction of import flow to curb the effect of inflation on the country's economy. The mutual causation between import flow and the inflation rate was also suggested by the study of Tuğcu et al. (2019) on the Turkish Economy. In this study, instead of the analysing impact of inflation on import flows, he analysed how inflation is affected by imports and the results indicated that high import flows cause increases in the inflation rate. The effect of inflation on imports, however, differs from country to country. The results of a study conducted by Ofori et al. (2015) indicated a negative relationship between inflation and import flows in Ghana for the period from 1960 to 2015. Similar results were found in the study of Kiganda et al. (2017) in Kenya, where high inflation causes export growth and import decline.

2.2. Exchange Rate and Trade Theory

Although the relationship between, exports, imports and exchange rate vitality remain complicated owing to the way a country's currency is valued, the general assumption suggests a positive relationship between exports and weak domestic currency; and a negative relationship between the weak domestic currency and import flows (Congressional Research Service, 2020). The role of the exchange rate on national income and international trade is well elucidated in the theory of absorption. The theory hypotheses that the reflection or manifestation of exchange rate volatility on the economy takes time but as the domestic currency duplicates imports gradually become more expensive and its demand declines (Krueger 1996; Nusrate 2018). Additionally, the neoclassic theory argues that exports and imports play a crucial role in any country's economy and therefore they need special attention to improve the nation's wealth and economy (Vijayasri 2013) for exports level to determine the solicited exchange rate to acquire goods, services and other resources that are scarce within the domestic markets (Iuga 2020). Various researchers were interested in analysing the linkage between exchange rates and imports. Some of their findings are provided in the following paragraph.

As the trade between two or more countries involves the conversion of one currency into the other, the exchange rate is perceived as one of the drivers of global trade. However, irrespective of the central banks' role in making and implementing monetary policies of their respective countries' currencies, various authors posit that a movement of free and independent exchange rates does not depend on the central bank's policy interventions. The foreign exchange rate is rather determined by the mechanism of demand and supply (Alam & Ahmed, 2012; Bailey 2009; Bhattarai 2011). Additionally, Curcuru et al. (2009) and Crucini et al. (2009) maintain that some monetary policies may impede the exchange rate movement. Therefore, the optimal level of the foreign exchange rate should be determined by the market's reactions towards the supply and demand mechanism.

Several studies were conducted to determine the relationship between exchange rate and trade components namely imports and exports. Given that monetary policies and market behaviour differ from country to country, it is not surprising that a dichotomy is experienced in findings on the relationship between import flows and exchange rates. Consequently, exchange rate volatility can have either a positive or negative impact on trade flows (Bahmani-Oskooee and Aftab 2017). Additionally, there is a third possibility that the exchange rate has no significant effect on trade flows (Chang et al. 2020). The study conducted by Iuga (2020), investigated the linkage between the exchange rate and imports in the Rumania economy and findings indicated a positive relationship between imports and exchange rate. The study indicated that the positive relationship between these two variables explained the presence of a trade deficit in the Rumania economy since 2000. On the other hand, Khan et al. (2014), Akpokodje and Omojimite (2009) found an inverse relationship between exchange rate volatility and import flows. Contrary to these results, Chang et al. (2020)'s study on the effect of exchange rate on the USA imports from developing countries suggested no significant evidence of exchange rate on the USA import flows from developing countries. In summary, findings on the effect of exchange rate volatility on trade suggest a negative effect (Kim 2017; Pino et al. 2016; Bahmani-Oskooee et al. 2015; Krugman 2007); positive effect (Bahmani-Oskooee et al. 2014; Bahmani-Oskooee et al. (2017); and no relationship (Aftab et al. 2017; Wong, 2017; Haile & Pugh 2013; Bahmani-Oskooee et al. 2013).

It is important to highlight that a close relationship exists between interest rate and inflation rate. A high inflation rate leads to an increase in the interest rate and the rate results in a borrowing rate decline which implies low access to funds. As imports depend on consumers' purchasing power, high inflation means low demand for imported goods and services. Additionally, high inflation causes a depreciation of domestic currency making import flow very expansive (Board of Governors of the Federal Reserve System 2022).

2.3. A brief literature on electricity supply in South Africa

Energy consumption, specifically electricity, plays an important role in the South African economy as the country supplies about 40percent of the aggregate electricity in Africa (Eskom, 2019); electricity share from total energy consumption in South Africa count for 28 percent (Trollip et. al. 2014). The role of electricity in South Africa is not restricted to economic activities, as it is also crucial in social welfare as well as health care system. However, the mismatch between electricity supply and demand has been an ongoing challenge for South Africans.

The issue of electricity supply supply-demand and its significance has its roots in the country's history. Since its introduction into the South African livelihood in 1860, electricity was the source of political, economic and social transformation (Kamanzi 2021). However, during the apartheid ruling system, the main concern or focus was the electricity supply as electricity was only demanded by the minority white people. Therefore, government had no interest in introducing electricity formal regulations (Baker and Phillips 2019). Consequently, policies initiated during this period did not meet the targeted objectives. In 1998, the South African government introduced a policy that aimed of restructuring and liberalization of the electricity supply industry (ESI) to bring equilibrium between demand and supply. Nonetheless, that policy has remained in the "white paper" as it was not implemented, and therefore, did not produce the anticipated results (Yelland 2020).

With the advent of democratic government in 1994, which considered access to electricity as one of the basic needs and a right to each citizen, electricity demand hand significantly increases. As several black South African could also access to electricity, the government created a Department of Energy (DoE) to deal with the issue of the miss much between electricity supply-demand (Baker & Phillips, 2019). However, this department did not achieve much as the power of planning and producing remained in Eskom hands (Baker, 2016). Owing to high demand and low supply of electricity, the South African Electricity Supply Commission (ESCOM) usually know as Eskom, introduced a rolling blackouts or load shedding commenced in 2005, repeated in 2007/8 and since 2014 electricity supply shortage remains a serious economic, social and chronic challenge (Akpeji et al. 2020; Nkosi & Dikgang 2018).

The electricity shortage causes disruption in businesses operations as it leads, for example, to stifling of the supply of cold and frozen food, depletion of aggregate production, backup batteries of fire systems, and decline in income generation

(Mabugu and Inglesi-Lotz 2022). These repercussions of low electricity supply in South Africa are more likely to affect the country's trade balance. Various empirical studies were conducted to analyse the effect of electricity supply revealed that adequate electricity supply enhance industrial output and thereafter leading to export growth (Akankunda et al. 2022; Alley et al. 2016; Baker 2016; Baker and Phillips 2019; Olufemi 2015). However, to the best knowledge of authors, no study investigated impact of electricity supply on South African import flow. This study aimed at filling that gap. Although, the current study focuses on the importance of electricity or energy in the South African context, some other studies were conducted and their findings highlighted the importance role played by the availability and stability of energy not only for trade and economic growth but also for global wellbeing. Those studies includes Abban et al. (2023), Nuta et al. (2015) and Zhang et al. (2023).

3. Materials and Approaches

3.1. Data Description

Empirical analysis of the relationship among the study variables employed monthly time series data from January 2002 to October 2022. Therefore, the study analysis is built on 240 monthly observations. The dependent or response variable is repressed by total import flows (IMP) of all items from abroad to South Africa. The South African import flows are measured in Rand (South African currency) and adjusted every month. Explanatory variables for the study are real effective exchange rate (RER), electricity supply (ELS) measured in Gigawatt-hours, and inflation calculated from the Consumer Price Index (CPI) for both Rural and Urban Consumers. The selection of the sample and independent variables was based on the data availability and linkage provided by the existing literature. We should expect that changes in the exchange rate, inflation and electricity supply may have a significant effect on the export flow in South Africa. The time series data for import flows and electricity supply were sourced from Statistics South Africa (Stats SA) while real effective exchange rate inflation series were acquired from the South African reserve Bank (SARB). All the study variables were transformed into a natural logarithm to avoid outliers and multicollinearity.

Table 1. Represents the Study Variables, Their Measurement and Sources.

Variable	Variable name	Measurement	Source
IMP	import flows	Millions of rand	Stats SA
RER	real effective exchange rate	(NEER * CPI Domestic) / (CPI Foreign)	SARB
ELS	electricity supply	Gigawatt-hours	Stats SA
CPI	Inflation	CPI	SARB

Note: NEER= Nominal Effective Exchange Rate

Table 2 displays the summary statistical properties of employed variables. All variables' means are positive and the import flows variable (LIMP) records the largest mean, while inflation (LCPI) records the smallest. Additionally, the largest standard deviation occurs in imports while the smallest is displayed in electricity supply. The skewness values in the table indicate that all variables are negatively skewed, inferring a large frequent tendency towards the negative tail of the distribution. The Kurtosis values indicate LIMP, LCPI and LRER have platykurtic distributions as the Kurtosis values are less than 3, this implies that outliers are infrequent in these series. Nonetheless, the LELS electricity supply series has a heavier tail than a normal distribution as its value falls under a Leptokurtic distribution.

Table 2. Summary Statistics

	LIMP	**LCPI**	**LELS**	**LRER**
Mean	10.78658	1.796611	4.265328	2.046232
Maximum	11.23455	2.028164	4.323355	2.150839
Minimum	10.21865	1.569704	4.149865	1.880165
Std. Dev.	0.245325	0.134832	0.026308	0.054874
Skewness	-0.530064	-0.008014	-0.751826	-0.323149
Kurtosis	2.194034	1.652108	4.420217	2.782665
Observations	250	250	250	250

3.2. Correlation

A correlation analysis is used to assess whether an association exists between two observed variables and determine both the strength and direction of the existing correlation (Schober & Schwarte 2018). There exist various types of correlations that include Kendall rank correlation, Pearson correlation, Point-Biserial correlation and Spearman correlation. These mentioned types of correlation are grouped into static and dynamic correlation. To determine the correlation or co-movement between variables under consideration, we performant the Pearson correlation test. The Pearson correlation is known to be static and informative in establishing a dynamic association between the variables (Coleman and Leone 2015). Consequently, we perform this test to assess the magnitude and direction of the correlation between series. To obtain the result displayed in Table 2, the subsequent Equations were estimated:

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i-\bar{x})\,(y_i-\bar{y})}{\sqrt{\left[\sum_{i=1}^{n}(x_i-\bar{x})^2\right]\left[\sum_{i=1}^{n}(y_i-\bar{y})^2\right]}} \qquad (1)$$

Where $\bar{x}$ and $\bar{y}$ denote the sample mean of $\bar{x}_1, \bar{x}_2, \dots, \bar{x}_n$ and $\bar{y}_1, \bar{y}_2, \dots, \bar{y}_n$, respectively.

Accordingly $$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \quad (2)$$

$$\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i \quad (3)$$

Alternatively, the correlation coefficient between variables *x* and *y* can be expressed as:

$$r_{xy} = \frac{\sum_{i=1}^{n} x_i y_i - n\bar{x}\,\bar{y}}{\sqrt{[\sum_{i=1}^{n}(x_i^2) - n\bar{x}^2]\,[\sum_{i=1}^{n}(y_i^2) - n\bar{y}^2]}} \quad (4)$$

It is important to highlight that the Pearson correlation coefficient varies between -1 and 1 and it can be expressed also as $-1 \le r \le 1$. It is called a perfect positive correlation if $r = +1$ and a perfect negative correlation if $r = -1$. Thus, the closer the value of r is to 1 or –1, the stronger the linear correlation between variables. Table 3 represents the results from Pearson's correlation test for the current study. While the correlation coefficient between inflation and import is high (>0.85) and significant at a 1 percent level, correlation coefficients between import and other explanatory variables are statistically significant yet small, implying a weak movement between those variables and import volume. It is important to highlight that the study variables were transformed into natural logarithms to ensure the consistency and accuracy of findings.

Table 3. Correlation Matrix

Variable and T-statistics	LIMP	LCPI	LELS	LREER
LIMP	1			
T-Stat	-----			
LCPI	0.935	1		
T-Stat	41.763*	-----		
LELS	0.323	0.144	1	
T-Stat	5.374*	2.298*	-----	
LREER	-0.304	-0.305	0.244	1
T-Stat	-5.026*	-5.057*	3.967*	-----

*Note: *indicates significance at 5% level.*

3.3. Bounds Test Approach

Pesaran and Pesaran (1997) introduced a new cointegration approach whose name is Autoregressive Distributed Lag (ARDL) model. The approach was revised by Pesaran and Shin (1999) and then improved by Pesaran *et al.* (2001). The core purpose of the approach is to assess the existence of a relationship between the explained or response variable and a group of repressors. The approach has various advantages over the traditional cointegration approaches. These advantages include the ability to produce valid results when applied to small data samples and its applicability to a mixture of I(0) and I(1) variables (Haug 2002; Pesaran and Shin 1999). The ARDL model estimation for the current study is expressed as follows:

$$\Delta LIMP_t = \varphi_0 + \sum_{i=1}^{p} \varphi_1 \Delta LIMP_t + \sum_{i=1}^{p} \varphi_2 \Delta LCPI_t + \sum_{i=1}^{p} \varphi_3 \Delta LELS_t + \sum_{i=1}^{p} \varphi_4 \Delta LREER_t + \gamma_1 LIMP_{t-1} + \gamma_2 LCPI_{t-1} + \gamma_3 LELS_{t-1} + \gamma_1 LREER_{t-1} + u_t \quad (5)$$

Where φ_0 denotes the intercept, u_t is the error term while $\varphi_1, \ldots, \varphi_4$ and $\gamma_1, .., \gamma_4$ represent short-run and long-run coefficients respectively. Given its power over other lag selection criteria (Pesaran & Shin, 1999), the Schwarz Bayesian Criteria (*SBC*) was selected to determine the optimal lag for each variable in the model. To determine the existence of a long-run relationship among variables, through the Wild test, we estimated the value of the F-statistics in the appropriate ARDL model. The obtained F-statistics were compared to the value of both upper and lower critical bounds. The null hypothesis of no cointegration ($H_0: \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = 0$) was tested against the alternative ($H_0: \gamma_1 \neq \gamma_2 \neq \gamma_3 \neq \gamma_4 \neq 0$). According to Pesaran *et al.* (2001), the lower bound critical value suggests that all the underlined variables are integrated of I(0), whereas the upper bound critical value suggests that all the underlined variables of the study are integrated of I(1). Consequently, the null hypothesis is rejected and the study variables cointegrate only if the F-statistic exceeds the upper bound critical value. The presence of cointegration among variables leads to the estimation of the subsequent long-run relationship coefficients:

$$LIMP_t = \varphi_0 + \sum_{i=1}^{p} \varphi_1 LIMP_t + \sum_{i=1}^{p} \varphi_2 LCPI_t + \sum_{i=1}^{p} \varphi_3 LELS_t + \varphi_4 \sum_{i=1}^{p} \varphi_3 LREER_t + u_t \quad (6)$$

The evidence of cointegration between import flow, inflation, electricity supply and exchange rate fluctuations implies the estimation of the error correction model (ECM) and short-run relationship coefficients as follows:

$$\Delta LIMP_t = \omega_0 + \sum_{i=1}^{p} \omega_1 \Delta LIMP_t + \sum_{i=1}^{p} \omega_2 \Delta LCPI_t + \sum_{i=1}^{p} \omega_3 \Delta LELS_t + \sum_{i=1}^{p} \omega_4 \Delta LREER_t + \delta ECM_{t-1} + u_t \quad (7)$$

Where ω_1, ω_2, ω_3 and ω_4 denote the short-run dynamic coefficients of the model. The ECM represents error the correction term while δ is the ECM coefficient and is expected to be negative and statistically significant.

3.4. Toda-Yamamoto (T-Y) Causality Test

In addition to the ARDL model used to determine the relationship among the study variables, we have also employed the Toda-Yamamoto causality test to establish the causation effect between import flows, inflation, electricity supply and exchange rate in South Africa. This approach was selected to overcome the traditional Granger causality test limitations. Toda and Yamamoto (1995) introduced a causality test that employs the Modified WALD test and AR (*k*). This test is built on the Vector autoregressive *(P=K+Dmax)* that correct*s VAR* order *K* by adding *d* and the latter denotes the maximum integration order of a given time series. One of the advantages of the T-Y test is its ability to provide accurate results on a mixture of I (0) and I(1) variables. Given that the T-Y non-causality test is built upon the VAR model where each variable in the system is treated as dependent, therefore, the following equations were estimated for the study:

$$LIMP_t \; \propto_0 + \sum_{i=1}^{k} \beta_{1i} LIMP_{t-1} + \sum_{j=k+1}^{d_{max}} \beta_{2j} LIMP_{t-j} + \sum_{i=1}^{k} \gamma_{1i} LCPI_{t-1} + \sum_{j=k+1}^{d_{max}} \gamma_{2j} LCPI_{t-j} + \sum_{i=1}^{k} \delta_{1i} LELS_{t-1} + \sum_{j=k+1}^{d_{max}} \delta_{2j} LELS_{t-j} + \sum_{i=1}^{k} \theta_{1i} LREER_{t-1} + \sum_{j=k+1}^{d_{max}} \theta_{2j} LREER_{t-j} + u_{1t} \quad (8)$$

$$LCPI_t \; = \propto_2 + \sum_{i=1}^{k} \gamma_{1i} LCPI_{t-1} + \sum_{j=k+1}^{d_{max}} \gamma_{2j} LCPI_{t-j} + \sum_{i=1}^{k} \beta_{1i} LIMP_{t-1} + \sum_{j=k+1}^{d_{max}} \beta_{2j} LIMP_{t-j} + \sum_{i=1}^{k} \delta_{1i} LELS_{t-1} + \sum_{j=k+1}^{d_{max}} \delta_{2j} LELS_{t-j} + \sum_{i=1}^{k} \theta_{1i} LREER_{t-1} + \sum_{j=k+1}^{d_{max}} \theta_{2j} LREER_{t-j} + u_{2t} \quad (9)$$

$$LELS_t \; = \propto_3 + \sum_{i=1}^{k} \delta_{1i} LELS_{t-1} + \sum_{j=k+1}^{d_{max}} \delta_{2j} LELS_{t-j} + \sum_{i=1}^{k} \gamma_{1i} LCPI_{t-1} + \sum_{j=k+1}^{d_{max}} \gamma_{2j} LCPI_{t-j} + \sum_{i=1}^{k} \beta_{1i} LIMP_{t-1} + \sum_{j=k+1}^{d_{max}} \beta_{2j} LIMP_{t-j} + + \sum_{i=1}^{k} \theta_{1i} LREER_{t-1} + \sum_{j=k+1}^{d_{max}} \theta_{2j} LREER_{t-j} + u_{3t} \quad (10)$$

$$LREER_t \; = \propto_4 + \sum_{i=1}^{k} \theta_{1i} LREER_{t-1} + \sum_{j=k+1}^{d_{max}} \theta_{2j} LREER_{t-j} + \sum_{i=1}^{k} \delta_{1i} LELS_{t-1} + \sum_{j=k+1}^{d_{max}} \delta_{2j} LELS_{t-j} + \sum_{i=1}^{k} \gamma_{1i} LCPI_{t-1} + \sum_{j=k+1}^{d_{max}} \gamma_{2j} LCPI_{t-j} + \sum_{i=1}^{k} \beta_{1i} LIMP_{t-1} + \sum_{j=k+1}^{d_{max}} \beta_{2j} LIMP_{t-j} + u_{4t} \quad (11)$$

3.5. Unit Root Test

Although the ARDL model can produce accurate results when applied to I(0) and/or I(1) variables, the model is not appropriate for variables that integrate after the second difference or I(2). Therefore, it is indispensable to conduct either a unit root or stationarity test to ensure the selection and usefulness of the model. The current study employed both the Augmented Dickey-Fuller (*ADF*) and Phillip Perron (*PP*) unit root tests. The ADF estimation is based on the subsequent equation:

$$\Delta Y_t \; = \propto_0 + \propto_1 Y_{t-1} + \sum_{j=1}^{k} d_j \Delta Y_{t-j} + \varepsilon_t \quad (12)$$

Where Δ is the first difference operator, $\propto_0$ denotes the intercept or constant, Y_t represents the considered time series, *k* denotes the optimum number of lags and ε_t

is the error term (white noise). The ADF test assesses whether the estimated coefficient of Y is zero. The series is stationary (has no unit root), it the estimated coefficient is smaller than the ADF critical value from the table.

Another test that assists in testing unit roots within a given series is the Phillip and Perron unit root test. The latter test is entrenched on t-statistics associated with the estimated coefficient as displayed in the following equation 13.

$$\Delta Y_t = \propto + \rho^* Y_{t-1} + \varepsilon_t \qquad (13)$$

4. Empirical Analysis and Result Interpretation

4.1. Unit Root Tests and Results

As mentioned in the previous section the current study employed the Augmented Dickey-Fuller (ADF) and Phillips–Perron (PP) to determine the integration order of the study variables. Table 4 displays the unit root test results. Both employed unit roots test to confirm a mixture of integration order of I (0) and I (1) for the study series. Based on these results, the ARDL model is the appropriate approach for cointegration assessment.

Table 4. Unit Root Results

Variables		**Levels I(0)**		**1st Difference I(1)**		Decision
		ADF	**PP**	**ADF**	**PP**	
IMP	Intercept	0.566	0.947	0.004**	0.000**	
	Trends	0.351	0.000**	0.013**	0.000**	I(0)
CPI	intercept	1.000	1.000	0.000**	0.000**	I(I)
	Trends	0.971	0.979	0.000**	0.000**	
ELS	intercept	0.127	0.000**	0.000**	0.000**	I(0)
	Trend	0.515	0.000**	0.000**	0.000**	
RER	Intercept	0.025**	0.012**	0.000**	0.000**	I(0)
	Trend	0.022**	0.013**	0.000**	0.000**	

*Note: ** statistically significant at 5% level*

4.2. Bound Testing Approach

Prior to the F-statistics estimation, we selected the ARDL model and its appropriate optimum number of lags. This was performed automatically through E-views software. The best-selected model was ARDL (3, 3, 3, 2). The results from F-statistics with corresponding critical values are depicted in Table 5. The value of calculated F-statistics, 20.06361, is greater than all the upper bound critical values in the table. This suggests that the null hypothesis of no cointegration is rejected in favour of the alternative. Consequently, a cointegration exists between import flows, inflation, electricity supply and exchange rate volatility.

Table 5. Results of Bound Testing for Cointegration

Null Hypothesis	No long-run relationships among variables					
Test Statistic	20.06361					
Critical values	**1%**		**5%**		**10%**	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
	4.29	5.61	3.23	4.35	2.72	3.77

4.3. Long-Run Coefficients Analysis

The variables' long-run coefficients in Table 5 are all statistically significant to influence long-run changes in the South African import flows. Inflation and electricity supply have a positive long-run effect on import flows while the exchange rate has an inverse effect on import flows. Ground on the coefficients in the table, electricity supply has the highest impact on import flows, in South Africa, compare to other explanatory variables. A one percent increase in supplied electricity units causes imports to flow to increase by 3.7 percent while a one percent increase in inflation rate leads to a 1.55 percent increase in import flows. Contrary to electricity supply and inflation, a one percent increase in exchange rate because of the South African import decline by 0.03 percent. These findings are different from general expectations as one would think that increasing electricity would increase local production and reduce demand for external imports. Two justifications might support these results. The first one is that products that require high use of electricity might also require imported raw or semi-finished material used for production, and the presence of enough energy would allow industries to increase their demand for input. The second explanation might be that the majority of South Africans who get monthly income work in a place where electricity plays a critical role in their activities, thus less electricity supply means fewer activities and less income. With less income demand for goods and services declines. On the other hand, high inflation means the low purchasing power of the South African currency. However, since the South African currency is high compared to the currency of the majority of neighbour countries, inflation might reduce the purchasing power of domestic products and leave products from neighbour countries less expensive compared to the domestic ones. Linking the inflation and exchange rate effects on imports, it can be concluded that Import flows are more sensitive to the exchange rate than the inflation rate. If the South African currency is considered weak compared to other currencies, the abroad product becomes more expensive and their demand declines. This study's findings oppose those of Abumdallala (2019), Ahmed et al. (2018), Islam (2013) and Muktadir-Al-Mukit et al. (2015), Okpe and Ikpesu (2021) and, Sahoo and Sethi (2018) whose findings suggested a positive relationship between inflation and import flow. Additionally, a negative long-run relationship between imports flow and exchange rate was found by Akpokodje and Omojimite (2009), Bahmani-Oskooee et al. (2015), Khan et al. (2014), Kim (2017), Krugman (2007), and Pino et al. (2016).

Table 6. Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCPI	1.553098	0.058550	26.526034	0.0000
LELS	3.697232	0.391519	9.443312	0.0000
LREER	-0.032028	0.170272	-0.188100	0.0251
C	-7.756907	1.621509	-4.783759	0.0000

4.4 Analysis of Short-Run Dynamics and Error Correction Model (ECM)

As highlighted in the methodology section, the presence of long-run relationships among variables requires, ipso facto, the estimation of the ECM and short-run changes. The results in Table 7 indicate that the error correction term of -0.323291 meets the expectation as it is negative and statistically significant at a 1 percent level. The value of this coefficient implies that at least 32.3 percent of shocks or deviation from long-term equilibrium is eradicated every month. It will, therefore, take approximately 3.09 (1/0.323291) months to re-establish the long-run equilibrium in the import flows system.

All short-run coefficients are statistically significant at 0.01 level, suggesting that the selected macroeconomic variables influence the behaviour of the South African import flows in the short run. In the short run, the import flows level is negatively influenced by its previous level. This might suggest that if more were previously imported the current level of import will be lower compared to what was imported in the previous month. In addition, import flows respond negatively to short-run changes in both electricity supply and real effective exchange rate. This implies that a short-run increase in electricity supply and exchange rate decreases the South African import flows.

Table 7. ECT and Short-Run Dynamics

Variable	Coefficient	Std. Error	t-Statistic	Probability
D(LIMP(-1))	-0.209609	0.057610	-3.638416	0.0003
D(LIMP(-2))	-0.204202	0.054918	-3.718282	0.0003
D(LCPI)	3.840249	1.386063	2.770616	0.0060
D(LCPI(-1))	2.907390	2.290685	1.269223	0.2056
D(LCPI(-2))	2.312940	1.395462	1.657472	0.0988
D(LELS)	1.078584	0.130884	8.240769	0.0000
D(LELS(-1))	-0.147969	0.147549	-1.002849	0.3170
D(LELS(-2))	-0.586187	0.141274	-4.149284	0.0000
D(LREER)	-0.157282	0.132775	-1.184581	0.2374

D(LREER(-1))	-0.660505	0.133471	-4.948678	0.0000
ECT	-0.323291	0.040532	-7.976109	0.0000

4.5. Causality Analysis

The existence of a long-run relationship between two or more variables implies that there should at least be one unidirectional causation. In other words, since the cointegration was established between import flows, inflation, electricity supply and exchange rate volatility it is indispensable to estimate their causal relationships. As the unit root results revealed the existence of integration order [I (0) and I (1)] within the estimated variables traditional Granger causality test would not be able to provide a robust causality outcome. Therefore, we employed the Toda-Yamamoto Granger non-causality test to determine causality and the direction between variables. As depicted in Table 7, the Toda-Yamamoto results support the short-run and ECM results. All explanatory variables have the power to cause a change in short-term import flows. Additionally, the dependent variables (import flows) are statistically significant to influence the behaviour of explanatory variables in the short run. In other words, a bidirectional causality exists between Import flows, inflation rate, electricity supply and exchange rate volatility in the South African economy.

Table 8. T-Y Granger causality results (Chi-square & P-values)

	Dependent variable			
Excluded lags	LIMP	LCPI	LELS	LREER
LIMP	----------	47.98926 (0.0000)	13.75376 (0.0010)	25.29032 (0.0000)
LCPI	9.761526 (0.0076)	----------	2.216416 0.3302	5.352215 0.0688
LELS	7.238107 (0.0268)	3.793088 (0.1501)	----------	5.301503 (0.0706)
LREER	7.202798 (0.0273)	0.674999 0.7136	1.028131 0.5981	----------

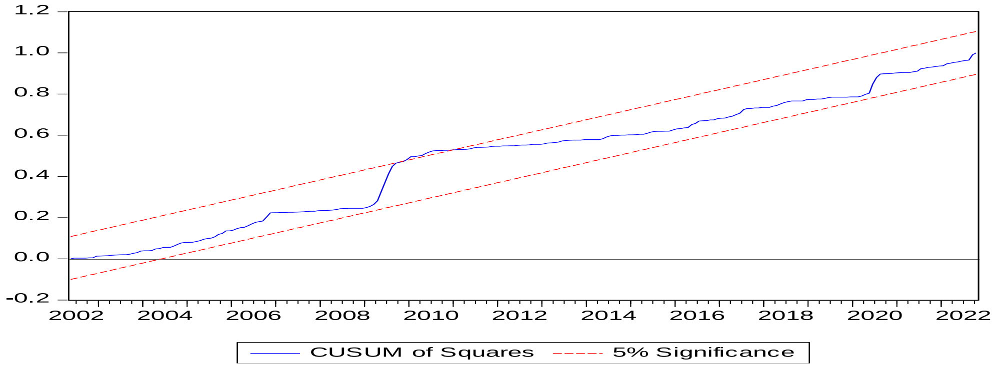
Note: P-values in the ()

4.6. Models and Findings Robustness Check

Prior to the interpretation of the obtained results, we conducted stability tests and residual tests to confirm the robustness of employed ARDL and T-Y models and the reliability of the findings. Results from these tests are summarised in Table 9. The null hypotheses for heteroscedasticity, normality and serial correction could not be rejected as their probability values exceeded 0.05. Additionally, the result from the Ramsey RESET indicated that the ARDL and T-Y models were correctly specified. Furthermore, the CUSUMSQ graph confirmed stability in the model parameters. This implies that the relationship between import flows, inflation rate, electricity supply and the exchange rate was consistent during the period of the study sample.

Table 9. Short Run and ECM Results

Tests	Jarque-Bera	Ramsey's Test	RESET	LM Tests	ARCH
Value for J-B	5.560	……..		……..	…….
F-statistic	……..	2.370		0.989	0.002
Prob. F	……...	……		0.3734	0.967
p-value	0.0620	0.0958		0.3487	0.966



5. Conclusion

Import flows is one of the macroeconomics key variables that determine the economic standard of a given economy as it allows the country to acquire or bring non-existent, quality and low-cost products into its market. Nonetheless, the import flow of a country is determined by other economic components. The study offered an empirical analysis of the relationship between import flows, inflation rate, electricity supply and exchange rate fluctuation within the South African Economy. To achieve the main objective, the researcher applied the Autoregressive Distributed Lag (ARDL) model, Error Correction Model and Toda-Yamamoto model on monthly time series from January 2002 to October 2022. Analysed series was sourced from Quanted EasyData.

The current study findings established the presence of a long-run relationship between import flows, inflation rate, electricity supply and exchange rate. Findings revealed a positive long-run relationship between inflation, electricity supply and import flows in South Africa. From these results, one can conclude that high inflation, and a stable and adequate electricity supply influence import flows in South Africa. On the other hand, exchange rate volatility was found to impede import flow. This implies that to enjoy more products from the foreign market, the South African currency should be strong and stable. Additionally, the causality test supported the long-run results suggesting that electricity supply, exchange rate volatility and inflation rate remain some of the major causes of import flows behaviour within the South African economy. The study finding provided significant information. Firstly, the study results indicated that exchange rate volatility and inflation rate play an important role in terms of South African trade openness and international trade. Secondly, it was revealed that stability in electricity supply influences the role played by the South African economy within global markets.

Based on the study findings south African economy is still having a room to improve its international trade relations. However, some rigorous decisions have to be made and both monetary and fiscal policies that favour positive openness must be implemented. In this regards, South African policymakers have to be more conscious while selecting the country's adequate exchange rate regime. In other words, exchange rate regime that maintain the strength and stability of the domestic currency is recommended. To increase production and conservation of produced goods, government authorities must ensure that sufficient and uninterrupted the electricity is supplied. Additionally, owing to its disruption on low material procurements, production and supply of final products; inflation rate must be kept stable at its possible lowest. Not only this will improve terms of trade it will also enhance the country's economy.

Irrespective of the study contribution, imports flow is associated and influenced by many economic and noneconomic factors. However, the current study was only limited to the role of inflation rate, electricity supply and exchange rate in determining shocks in imports flow in South Africa. To overcome these limitations, future studies should consider increasing the number of the explanatory variables in the model. Additionally, non-economic factors such as political risk and climate change should be considered while assessing the determinant of import flows in South Africa.

Reference

Abban, O. J.; Xing, Y. H.; Nuţă, A. C.; Nuţă, F. M.; Borah, P. S; Ofori, C. & Jing, Y. J. (2023). Policies for carbon-zero targets: Examining the spillover effects of renewable energy and patent applications on environmental quality in Europe. *Energy Economics*, *126*, 106954.

Abumdallala, S. M. (2019). The Relationship between Imports and Inflation in Palestine: Toda and Yamamoto Causality Analysis. *International Journal of Business Administration*, 10(2), pp. 17-21.

Ahmed, R. R.; Ghauri, S. P.; Vveinhardt, J. & Streimikiene, D. (2018). An empirical analysis of export, import, and inflation: a case of Pakistan. *Romanian journal of economic forecasting*, *21*(3), pp. 117-130.

Ahmed, R. R.; Ghauri, S. P.; Vveinhardt, J. & Streimikiene, D. (2018). An empirical analysis of export, import, and inflation: a case of Pakistan. *Romanian journal of economic forecasting*, 21(3), pp. 117-130.

Akankunda, B.; Nkundabanyanga, S. K.; Adaramola, M. S. & Angelsen, A. (2022). Industrial output in Uganda: Does electricity consumption matter? *Advances in Phytochemistry, Textile and Renewable Energy Research for Industrial Growth*, pp. 84-93. CRC Press.

Akpeji, K. O.; Olasoji, A. O.; Gaunt, C. T.; Oyedokun, D. T.; Awodele, K. O. & Folly, K. A. (2020). Economic impact of electricity supply interruptions in South Africa. *SAIEE Africa Research Journal*, 111(2), pp. 73-87.

Akpokodje, G. & Omojimite, B.U. (2009). The effect of exchange rate volatility on the imports of ECOWAS countries. *Social Sciences*, 4 (2), pp. 304–346.

Alam, S. & Ahmed, Q. M. (2012). Exchange rate volatility and aggregate exports demand through ARDL framework: An experience from Pakistan economy. *Review of Applied Economics*, *8*(1076-2016-87187), pp. 79-94.

Alley, I.; Egbetunde, T. & Oligbi, B. (2016). Electricity supply, industrialization and economic growth: evidence from Nigeria. *International Journal of Energy Sector Management*, 10(4), pp. 511-525.

Aye, G. C.; Gupta, R.; Moyo, P. S. & Pillay, N. (2015). The impact of exchange rate uncertainty on exports in South Africa. *Journal of International Commerce, Economics and Policy*, 6(01), 1550004.

Bahmani-Oskooee, M.; Hegerty, S. & Zhang, R. (2014). Exchange-rate risk and UK-China trade: evidence from 47 industries. *Journal of Chinese Economic and Foreign Trade Studies*, 7 (1): pp. 2-17.

Bahmani-Oskooee, M.; Hegerty, S. W. & Hosny, A. (2015). Exchange-rate volatility and commodity trade between the EU and Egypt: Evidence from 59 industries. *Empirica*, 42, pp. 109-129.

Bahmani-Oskooee, M.; Iqbal, J. & Khan, S. U. (2017). Impact of exchange rate volatility on the commodity trade between Pakistan and the US. *Economic Change and Restructuring, 50*, pp. 161-187.

Bailey, K. (2009). *Is South-South trade a testing ground for structural transformation?* New York.

Baker, L. & Phillips, J. (2019). Tensions in the transition: The politics of electricity distribution in South Africa. *Environment and Planning C: Politics and Space*, *37*(1), pp. 177-196.

Baker, L. (2016). Sustainability transitions and the politics of electricity planning in South Africa. In: Brauch, HG.; Oswald Spring U.; Grin J, et al. (eds) *Handbook on Sustainability Transition and Sustainable Peace*. London: Springer, pp. 793–809.

Bhattarai, K. (2011). Panel Data Models: Econometric Analysis. Hull University.

Board of Governors of the Federal Reserve System (2022). Federal Reserve Issues FOMC Statement. https://www.federalreserve.gov/newsevents/pressreleases/monetary20220126a.htm.

Chang, B. H.; Rajput, S. K. O.; Bhutto, N. A. & Abro, Z. (2020). Asymmetric effect of extreme changes in the exchange rate volatility on the US imports: Evidence from multiple threshold nonlinear autoregressive distributed lag model. *Studies in economics and finance*, 37(2), pp. 293-309.

Coleman, S. & Leone, V. (2015). An investigation of regime shifts in UK commercial property returns: a time series analysis. *Applied Economics*, *47*(60), pp. 6479-6492.

Congressional Research Service (2020). *The Dollar and the U.S. Trade Deficit*. https://crsreports.congress.gov/product/pdf/IF/IF11430/3.

Edwards, L. (2020). *Exports, Growth and Employment in South Africa*. School of Economics and PRISM, University of Cape Town.

Engle, R. (2002). Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models. *Journal of Business & Economic Statistics*, 20(3), pp. 339-350.

Eskom (2019). *Integrated Results for the year ended 31 March 2018*. Eskom: Johannesburg.

Filardo, AJ. & Gordon S.F. (1994). International comovement of business cycles, Federal Reserve Bank of Kansas City *Working Paper* 94–11, Federal Reserve Bank of Kansas City. Available at https://www.kansascityfed.org/publications/research/rwp (accessed 27 April 2023).

Gregory, A. W.; Head, A. C. & Raynauld, J. (1997). Measuring world business cycles. *International Economic Review*, pp. 677-701.

Haile, M. G. & Pugh, G. (2013). Does exchange rate volatility discourage international trade? A meta-regression analysis. *The Journal of International Trade & Economic Development*, 22(3), pp. 321-350.

Holden. M. & Gouws, A. (1997). Determinants of Exports in South Africa. *Trade and Industrial Policy Secretariat Annual Forum*. Glenburn Lodge.

Islam, M. A. (2013). Impact of inflation on import: An empirical study. *International Journal of Economics, Finance and Management Sciences*, 1(6), pp. 299-309.

Iuga, I. (2020). The Influence of The Exchange Rate on Imports–Romanian Case Study. *Ovidius University Annals, Economic Sciences Series*, 20(1), pp. 975-982.

Kamanzi, B. (2021). The crisis in South Africa's energy sector: Towards a just transition centring job creation and social ownership. *Working Document*, no 3. Johanesburg, Tricontinental: Institute for Social Research.

Khan, A. J.; Azim, P. & Syed, S. H. (2014). The impact of exchange rate volatility on trade: a panel study on Pakistan's trading partners. *The lahore journal of economics*, *19*(1), pp. 31–66.

Kiganda, E. O.; Obange, N. & Adhiambo, S. (2017). The relationship between exports and inflation in Kenya: An aggregated econometric analysis. *Asian Economic and Business Accounting*, 3(1), pp. 1-12.

Kim, C. B. (2017). Does exchange rate volatility affect Korea's seaborne import volume? *The Asian Journal of Shipping and Logistics*, *33*(1), pp. 43-50.

Krueger, A. O. (1996). *Determinarea Cursului Valutar*. Timisoara: Sedona Publishing House.

Krugman, P. (2007). Will there be a dollar crisis? *Economic Policy*, *22*(51), pp. 436-467.

Mabugu, T. & Inglesi-Lotz, R. (2022). The effect of mismatched supply and demand of electricity on economic growth in South Africa. *Energy Sources, Part B: Economics, Planning, and Policy*, 17(1), 2038731.

Muktadir-Al-Mukit, D.; Shafiullah, A. Z. M. & Ahmed, M. R. (2013). Inflation led import or import led inflation: Evidence from Bangladesh. *Asian Business Review*, *2*(2), pp. 65-69.

Nkosi, N. P. & Dikgang, J. (2018). Pricing electricity blackouts among South African households. *Journal of Commodity Markets*, 11, pp. 37-47.

Nusrate, A. & Ahmad, A.H. 2018. Exchange rate hysteresis in the UK imports from the South Asian Countries. *International Review of Economic and Finance*, 58, pp. 159-178.

Nuta, A. C.; Nuta, F. M.; Chirila, V.; Roman, A. & Pusca, A. C. (2015). Testing the relationship between public expenditure and economic growth in Romania. *Acta Universitatis Danubius. Œconomica*, 11(4).

Ofori, A.; Richardson, A. M. K. & Asuamah, S. Y. (2015). Modelling the Link between Inflation and Import in Ghana. *Journal of Empirical Economics*, *4*(1), pp. 49-62.

Okpe, A. E. & Ikpesu, F. (2021). Effect of Inflation on Food Imports and Exports. *The Journal of Developing Areas*, *55*(4), pp. 1-10.

Olufemi, O. J. (2015). The effects of electricity consumption on industrial growth in Nigeria. *Energy*, 6(13), pp. 54-59.

Pesaran, M. H.; Shin, Y. & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of applied econometrics*, 16(3), pp. 289-326.

Pesaran, M.H & Shin, Y. (1999) An autoregressive distributed lag modeling approach to co-integration analysis, in S. Strom (Ed.). *Econometrics and economic theory in the 20th century: the Ragnar Frisch centennial symposium*. Cambridge: Cambridge University Press.

Pesaran, M.H. & Pesaran, B. (1997). *Working with Microfit 4.0: interactive econometric analysis.* Oxford: Oxford University Press.

Pino, G.; Tas, D. & Sharma, S. C. (2016). An investigation of the effects of exchange rate volatility on exports in East Asia. *Applied Economics*, 48(26), pp. 2397-2411.

Rangasamy, L. (2009). Exports and economic growth: The case of South Africa. *Journal of International Development: The Journal of the Development Studies Association*, *21*(5), pp. 603-617.

Sahoo, M. & Sethi, N. (2018). The dynamic relationship between export, import and inflation: Empirical evidence from India. *The Indian Economic Journal*, *66*(3-4), pp. 294-311.

Samawi, G. A.; Mdanat, M. F. & Arabiyat, T. S. (2017). The role of energy supply in economic growth: Evidence from the oil importing countries. *International Journal of Energy Economics and Policy*, *7*(6), p. 193.

Schober, P.; Boer, C. & Schwarte, L. A. (2018). Correlation coefficients: appropriate use and interpretation. *Anesthesia & analgesia*, *126*(5), pp. 1763-1768.

Schober, P.; Boer, C. & Schwarte, LA. (2018) Correlation coefficients: appropriate use and interpretation. *Anest Anal* 126(5), pp. 1763-1768.

Tai, TT. (2022) The role of international trade in a world economy. *International Journal of Advanced Multidisciplinary Research Studies,* 2(6), pp. 717-726.

Trollip, H.A.; Butler, J.; Burton, T. & Caetano, C. (2014). *Energy security in South Africa. Developing Countries Exploring Pathways to Climate Compatibility* (17), pp. 1–32. https://media.africa portal.org/documents/Energy-Security_in-South-Africa.pdf. Retrieved February 2023.

Tuğcu, C. T.; Uzun, A. M. & Özkök, İ. (2019). The impact of import on inflation: An ARDL analysis for the Turkish economy. *Akdeniz İİBF Dergisi*, *19*(2), pp. 415-426.

Wong, H. T. (2017). Exchange rate volatility and bilateral exports of Malaysia to Singapore, China, Japan, the USA and Korea. *Empirical Economics*, 53, pp. 459-492.

World Bank. (2020). *Exports of goods and services (BoP, current US$) – world, South Africa, upper middle income'*. https://data.worldbank.org/indicator/BX.GSR.GNFS.CD?locations=1W-ZA-XT (accessed 30 April 2021).

Yelland, C. (2020). *South Africa's Energy Policies Are Changes Finally Coming?* Available online: https://www.ifri.org/sites/default/files/atoms/files/yelland_south_africa_energy_policies_2020.pdf (accessed on 31 March 2023).

Zhang, Z.; Nuță, F. M.; Dimen, L.; Ullah, I.; Xuanye, S.; Junchen, Y. & Yi, C. (2023). Relationship between FDI inflow, CO2 emissions, renewable energy consumption, and population health quality in China. *Frontiers in Environmental Science*, 11, p. 1120970.