

**AN ASSESSMENT OF THE VALUE OF PMI AND MANUFACTURING
SECTOR GROWTH IN PREDICTING OVERALL ECONOMIC OUTPUT (GDP)
IN SOUTH AFRICA**

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-Abstract-

Macroeconomic indexes are useful tools in forecasting long and short-run changes in the economy. The purpose of this study is to assess the usefulness of the Purchasing Managers' Index (PMI), and changes in the manufacturing sector as predictors of economic output. This study is quantitative in nature and employed an ARDL econometric model, vector error correction (VEC) and Granger causality approaches to determine the short and long-run relationships amongst the variables. The ARDL method was used as the variables had a mixture of stationarity at levels I(0) and first difference I(1). The model used economic output measured as GDP, as the dependent variable, while PMI, output in the manufacturing sector and CPI (used as the control variable) were the independent variables. Quarterly data sets were obtained from Statistics South Africa and the Bureau of Economic Research (BER) for the period 2000 to 2017. Findings of the ARDL estimation revealed that the variables cointegrate in the long run and changes in manufacturing output had the highest impact on long-run economic growth of the three variables. In the short run, all independent variables had a significant impact on economic growth. The main findings from the Granger causality tests indicate that bi-directional causality exists between both PMI and GDP as well as between PMI and manufacturing output. Additionally, bi-directional causality was found between GDP and manufacturing, while CPI just causes manufacturing changes. The implications of the research is the confirmation of the importance of PMI, CPI and output of the manufacturing sector as indicators for changes in overall economic activity on a macro level.

Key Words: ARDL, Economic output, MPI, South Africa.

JEL Classification: C32, E37

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1. INTRODUCTION

Macro-economic indexes such as the Purchasing Managers Index (PMI) and the Consumer Price Index (CPI) are linked to boom and bust business cycles. Periods of economic expansion lead to a rise in employment and increases in demand for commodities. This rise in general economic activities could lead to skills shortages and supply-chain problems. This situation usually results in excessive demand and supply shortages, leading to price increases and inflation due to higher production costs and demand (IHS Markit, 2017). Globally, PMI is recognised as the earliest leading indicator of possible changes in an economy (Tsuchiya, 2012). PMI surveys have been developed to analyse sections of the above-listed process and allow for analysis of economic growth patterns where data are available at the beginning of every month, in advance of most other macro-economic data sets. According to Khundrakpam and George (2013), PMIs are used by many central banks to analyse overall economic activities relating to strength and direction.

PMI is globally considered a leading indicator of economic activity and could be used as a forecaster of movements in GDP, inflation and especially manufacturing activity (Lindsey & Pavur, 2005; Tsuchiya, 2012). It should however be noted that the strength of PMI, as a leading indicator of economic activity, has in recent years lost some of its strength due to the diminishing role of manufacturing in the global economy (Barnes, 2017). According to Barnes (2017), PMI is however significant as most recessions of boom periods still start in the manufacturing sector. The main objective of the study is to determine the prediction value of PMI, and output in the manufacturing sector regarding total economic output measured as GDP. PMI is the main focus of the analysis with CPI only used as a control variable. The study uses secondary time series data and is founded on quantitative data in South Africa from 2000 to 2017. The study layout firstly includes a literature review, which consists of an analysis of definitions and concepts and an empirical review of quantitative results of previous studies; secondly, the research methodology is explained with the associated results and findings. Lastly, recommendations are made with some concluding remarks.

2. REVIEW OF LITERATURE

PMI is defined as a composite index that measures activity and growth in the manufacturing sector and also indirectly the total economy of a country (Chien & Morris, 2016). In addition, Aprigliano (2011) states that PMI provides timely information on the spread of improvement or deterioration of business conditions

without the measurement of the extent of the change. According to Joseph, Larrain and Turnerc (2011), PMI is a user-friendly and subjective survey to determine the state of the manufacturing sector in a region. It is a composite index which is compiled through surveys of purchasing and supply conditions of manufacturing firms in a country or region (Khundrakpam & George, 2013). The survey also indicates if manufacturing input and output costs have changed from quarter to quarter. It is a leading indicator of economic activity due to the fact that purchasing managers are surveyed on their purchase and productions conditions and decisions (Khundrakpam & George, 2013; Pelaez, 2003).

Although the use of the PMI has some drawbacks, such as the fact that it does not capture the intensity of changes or take into account the size of firms, it is an important measurement tool (Harris, 1991; Koenig, 2002; Lahiri & Monokroussos, 2012). According to Barnes (2017), purchasing managers in the monthly survey have to indicate in their response if conditions are better (increase), the same (unchanged) or getting worse (decreased). The PMI is a score between 0 and 100. For example, a PMI of 50 indicates that an equal number of managers indicated that conditions are better compared to getting worse. A PMI of 50 and above therefore indicates possible expansion of specifically the manufacturing sector and a value of 42 indicates GDP expansion (Koenig, 2002). In SA, the PMI is compiled by the BER on a monthly frequency based on the principles as used by the Institute of Supply Management (ISM) in the US. PMI consists of a number of components: production, new orders, employment, supplier deliveries and inventories (stock). The first surveys were completed in September 1999 (BER, 2015). PMI's strengths of a leading indicator are the freshness of its data, the power to explain and understand other indicators better, showing trends in changes and its' ability to analyse supply in the commodity sectors (Barnes, 2017). Weaknesses of the index are its subjectivity and that it just addresses the manufacturing sector (Barnes, 2017). PMI with its base as the manufacturing sector is a strong leading indicator for the broader economy due to its linkages to the primary and tertiary sectors of the economy and indicates cyclic changes.

In terms of empirical results from previous studies which analysed the relationships between the variables, the following results are presented from major world economies. PMI originated in the US; therefore results from the largest economy in the world are listed first. Concerning the US economy, Koenig (2002) tested the relationship regarding PMI, manufacturing performance and

GDP changes for the period 1948 to 2002. He found that a 1 point increase in PMI leads to a 1.54 point increase in manufacturing output, but only a 0.70 increase in subsequent quarters. He confirmed the threshold index of 50 for expansion of the sector. Subsequently, he also found a similar, but slightly weaker relationship between the PMI and GDP in the US. A 1 point increase in PMI leads to an increase of 0.57 in GDP and 0.28 in subsequent quarters. He confirmed a critical value of 41 for GDP expansion and concluded that PMI is at least a strong and reliable indicator of conditions of the manufacturing sector. Tsuchiya (2012) tested the relationship between PMI, the manufacturing sector and the overall US economy for the period 1991 to 2010. It was found that PMI was a significant predictor for manufacturing, but was not a significant predictor for change in the direction of GDP, possibly due to the declining share of manufacturing in the total economy. Banerjee and Marcellino (2006) also tested the relationship between PMI, inflation and GDP growth in the US and found a significant relationship between indicators. Koenig (2002) in his investigation of PMI and its predictability towards the manufacturing sector and overall GDP growth in the US, found that a PMI value of 47 indicated expansion of the manufacturing sector, while a value of 40 indicated GDP growth. A value of 52.5 indicated an increase in interest rates.

Chien and Morris (2016) found that PMI and GDP in the US and China were closely correlated with coefficients of 0.75 and 0.73 respectively and an index of 50 or more indicated positive GDP growth. According to Chin (2017), PMI in China is used with success and is seen as an early indication of the outlook for the manufacturing sector. In a study by Aprigliano (2011) in Italy from 1997 to 2010 in an econometric model, it was found that PMI has a significant relationship with manufacturing output and with GDP growth with the 50-threshold rule applicable. In India, for the period 2005 to 2012, using an ARDL econometric method, it was found that PMI was a significant predictor of inflation and economic activities and especially of manufacturing growth (Khundrakpam & George, 2013).

3. METHODOLOGY

This study assesses the value of PMI, and examines whether changes in the manufacturing sector's output and CPI are useful in predicting overall economic output in the South African economy. To achieve this objective, time series data from the first quarter of 2000 to the last quarter of 2017 is employed. This data was acquired from the South African Reserve Bank (SARB) and the Bureau of Economic Research (BER). The study uses data from 2000 because the

compilation of the PMI started at the end of 1999. The general discussion follows the following estimated model represented by Equation (1):

$$GDP_t = f(PMI_t, MANU_t, CPI_t) \dots \dots \dots (1)$$

Variables were transformed into natural logarithm form to provide reliable and consistent empirical estimations. Equation (2), following, is the model in the Equation (1) transformed into logarithmic form:

$$LnGDP_t = \beta_0 + \beta_1 LnPMI_t + \beta_2 LnMANU_t + \beta_3 LnCPI_t + u_t \dots \dots \dots (2)$$

In the Equation 2, $LnGDP_t$ is the natural logarithm of economic output (GDP) at the time t , $LnMANU$ is the natural logarithm total output in the manufacturing sector, $LnCPI_t$ is the natural logarithm of consumer price index (CPI) at time t , and u_t is the stochastic error term. In the econometric contest, two or more series are cointegrated if they have a long-run relationship (Brooks, 2008). Various approaches, in the econometric field, can be employed to determine whether time series cointegrate or not. Some of those approaches comprise Engle and Granger (1987) cointegration model, Phillips-Ouliaris's (1990) cointegration test, Johansen's (1991) maximum eigenvalue test, error correction model (ECM)-based F-test of Boswijk (1994), the ECM-based t -test of Banerjee, Dolado and Mestre (1998); and Bayer and Hanck's (2013) combined cointegration test. All of these mentioned tests require variables or series under consideration to have the same order of integration. The current study applied the ARDL bound test introduced by Pesaran, Shin and Smith (2001) to examine the long-run relationship amongst variables. The ARDL approach is known to be more flexible as it can analyse the long-run relationship among variables that possess different order of integration, thus, a mixture of $I(0)$ and $I(1)$ variables. Applying the ARDL Bounds test in ECM, it is not restricted to the number of lags, as well as a different number of lags can be included in the model and each variable can have its optimum number of lags (Laurenceson & Chai, 2003). Additionally, the ARDL model provides a better result than other models when applied on a small simple data set (Haug, 2002; Narayan, 2005). The ARDL approach also estimates the short and long-run simultaneously. Nonetheless, while applying the ARDL approach, the researcher has to ensure that none of the variables is $I(2)$. In this regard, the ARDL approach is the most suitable for this study because the series under consideration are $I(0)$ and $I(1)$. To determine the long-run relationship amongst variables, the following model is estimated (Equation (3)):

$$\Delta \text{LnGDP}_t = \alpha_0 + \sum_{i=1}^k \alpha_{1i} \Delta \text{LnGDP}_{t-i} + \sum_{i=0}^k \alpha_{2i} \Delta \text{LnCPI}_{t-i} + \sum_{i=0}^k \alpha_{3i} \Delta \text{LnPMI}_{t-i} + \sum_{i=0}^k \alpha_{4i} \Delta \text{LnMANU}_{t-i} + \beta_1 \text{LnGDP}_{t-1} + \beta_2 \text{LnCPI}_{t-1} + \beta_3 \text{LnPMI}_{t-1} + \beta_4 \text{LnMANU}_{t-1} + e_t \dots\dots\dots(3)$$

Where Δ is the first difference operator, α_0 is the component of drift, α_1 to α_4 are short run coefficients, β_1 to β_4 are long run coefficients, and e_t is the residual white noise. To investigate cointegration amongst variables, the Bounds test suggested by Pesaran, Shin & Smith, (2001) is estimated. In this procedure, the F-test is performed. The F-test assists in making decisions about the null hypothesis on no cointegration amongst variables against the alternative hypothesis suggesting the existence of cointegration among variables:

$$H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0 \text{ (no cointegration)}$$

$$H_A : \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0 \text{ (cointegration exists)}$$

Pesaran *et al.* (2001) suggested two critical values for the cointegration test. The lower critical bound assumes that variables are integrated of order zero $I(0)$, and the upper bound assumes that variables are integrated of order one $I(1)$. If the calculated F-statistic is greater than the upper bound critical value, the null hypothesis of no cointegration is rejected; meaning that a long-run relationship exists amongst the variables. However, if the F-statistic is lower than the lower critical value, the null hypothesis is not rejected; meaning the absence of a long-run relationship amongst the variables. In the presence of a long-run relationship or cointegration amongst the variables, the unrestricted error correction model (UECM) is performed. Equation (4) displays the ECM pertaining to variables estimated in Equation 3:

$$\Delta \text{LnGDP}_t = \alpha_0 + \sum_{i=1}^k \alpha_{1i} \Delta \text{LnGDP}_{t-i} + \sum_{i=0}^k \alpha_{2i} \Delta \text{LnCPI}_{t-i} + \sum_{i=0}^k \alpha_{3i} \Delta \text{LnPMI}_{t-i} + \sum_{i=0}^k \alpha_{4i} \Delta \text{LnMAN_OUT}_{t-i} + \varphi EC_{t-1} + u_t \dots\dots\dots(4)$$

Where φ denotes the speed of adjustment and EC denotes residuals abstained from cointegration estimation in Equation 3. The approaches that have been employed to determine the long-run relationship and its coefficients are additionally tested through some of the diagnostic tests such as serial autocorrelation, normality, heteroscedasticity and the stability tests. The CUSUM test is used for the model stability checks. Furthermore, the robustness of the techniques, as used in determining long and short-run, are employed to justify the study outcome.

4. RESULTS AND DISCUSSION

Table 1 displays the descriptive state of the preliminary data for analysis. The data for CPI is skewed to the left and also normally distributed, while the rest of the variables are skewed to the left and non-normal. Despite its normality, the data of CPI fluctuates more compared to the rest of the data as its standard deviation is 0.295501. The standard deviations of LnGDP, LnPMI, and LnMANU are 0.154881; 0.091200 and 0.107574, respectively.

Table 1: Descriptive Statistics

	LnGDP	LnPMI	LnMANU	LnCPI
Mean	14.7647	3.9329	12.7560	4.1609
Median	14.8023	3.9412	12.8042	4.1827
Maximum	14.9652	4.0859	12.8766	4.6472
Minimum	14.4717	3.6234	12.5285	3.6523
Std. Dev.	0.1548	0.0912	0.1075	0.2955
Skewness	-0.4770	-1.0766	-0.6533	0.0091
Kurtosis	1.8481	4.9937	1.8950	1.7282
Jarque-Bera	6.7114	25.8357	8.7856	4.8534
Probability	0.0348	0.0002	0.0123	0.0883

Figure 1 and 2 indicate the individual trends of the four variables. It is interesting to note the impact of the financial crises on both the GDP and manufacturing output during 2008 where the manufacturing output was affected more severely and did not fully recover. The PMI trends also reveals a low point from 2007 to 2009, with the lowest value of less than 40. The CPI indicates its negative relationship with the other variables.

Figure 1: Graphical trends of the variables (original raw data)

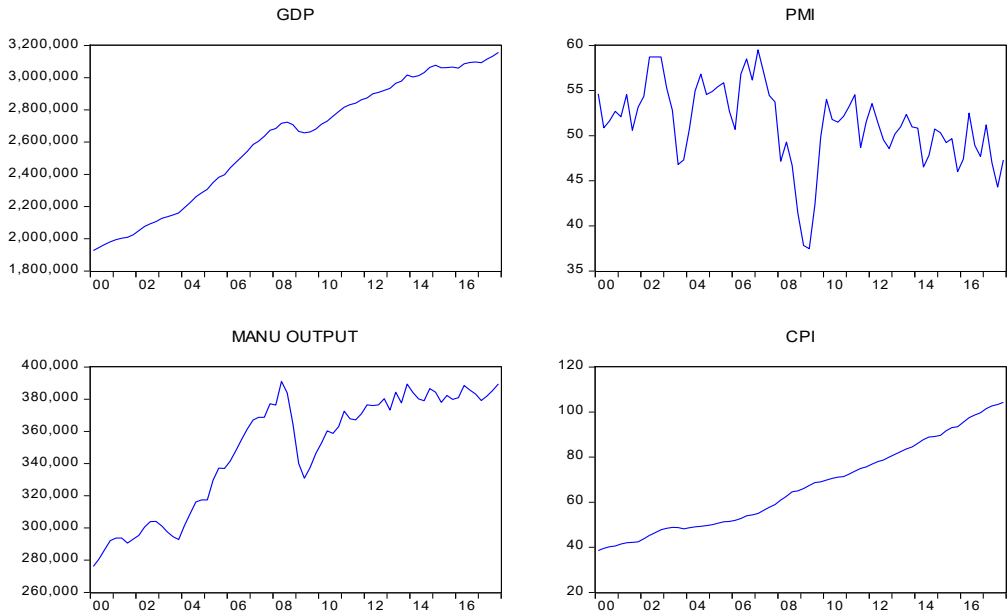
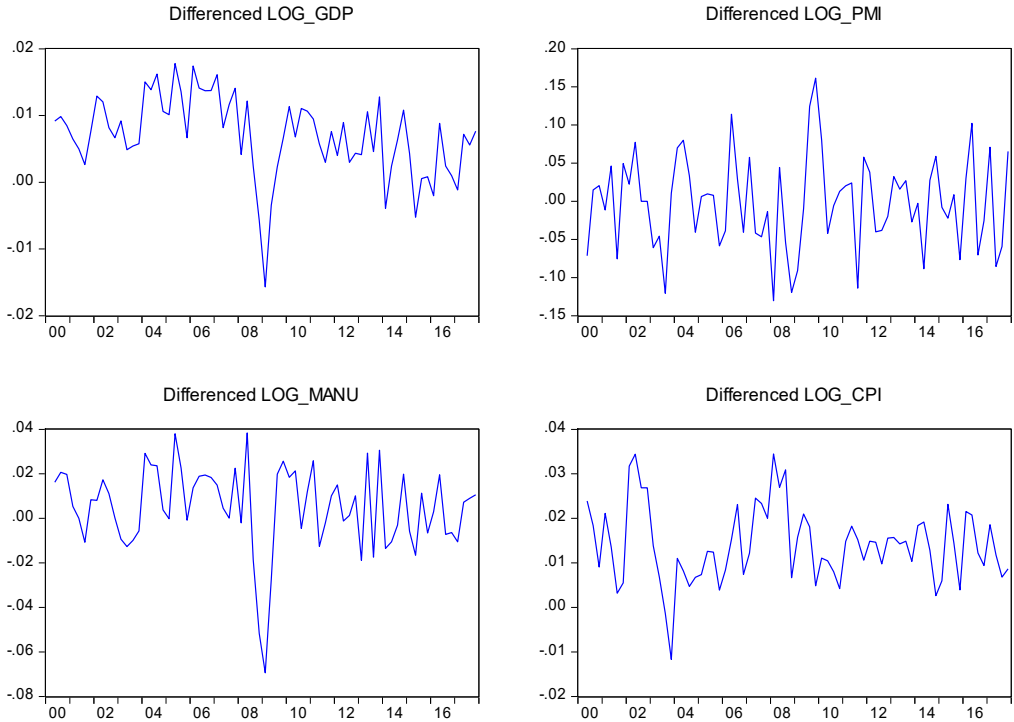


Figure 2: Graphical trends of the variables (logged and differenced data)



The first step before the cointegration analysis is to determine the order of integration for variables under the study. For this reason, a unit root test was performed using the Augmented Dickey-Fuller (ADF) test. The test results displayed in Table 2 indicate a mixture of the variables. While LnPMI is stationary at levels [I (0)], other variables are stationary after being first differenced [I (1)]. These results justify why the ARDL Bounds test is the appropriate approach to investigate whether or not variables are cointegrated in this case.

Table 2: Results of ADF unit root tests

Variables	Levels		First Difference	
	Constant	Constant and trend	Constant	Constant and trend
LnGDP	0.2893	0.9449	0.0005*	0.0009*
LnPMI	0.0122*	0.0138*	0.0000*	0.0000*
LnMANU	0.4679	0.3627	0.0000*	0.0000*
LnCPI	0.9149	0.1204	0.0001*	0.0004*

Note: * significance level at 5%

According to Pesaran *et al.* (2001), the ARDL approach assumes that just one cointegration or long-run relationship exists between the dependent and independent variables. To determine this cointegration, the F-statistics is computed and the results are presented in Table 3. The calculated F-statistic is greater than all upper bound critical values, even at 1 percent level. Therefore, a cointegration or long-run relationship exists amongst variables.

Table 3: Results of cointegration and bound testing results for ARDL Model

Test Statistic	Value	K
F-statistic	12.05708	3
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.72	3.77
5%	3.23	4.35
2.5%	3.69	4.89
1%	4.29	5.61

Source: Author’s calculation

The long-run model corresponding to the prediction of the South African economic output based on the three independent variables PMI, the total output in the manufacturing sector and CPI, is presented in Equation (5):

$$\text{LnGDP} = -1.8838 + 0.2681*\text{LnPMI} + 0.3878*\text{LnMANU} - 0.1907*\text{LnCPI}....(5)$$

In Equation (5), the elasticity of CPI is - 0.019. If CPI increases by 1 percent, economic output could decline by approximately 0.02 percent, which is not a significant impact. Contrary to the CPI that is negatively related to economic output, a 1 percent increase in PMI leads to 0.27 percent increase in economic output. Similar results were found by Koenig (2002) and by Banerjee and

Marcellino (2006). Economic output could increase by 0.39 percent with a 1 percent increase in the level of total output in the manufacturing sector. Since a long-run relationship between the dependent and independent variables was established, it is important to test whether the dependent variable could also be forecast based on the short-run results. It is also significant to determine the speed of adjustment following shocks in the system. The ECM coefficient -0.0495 is negative and statistically significant. It infers that there is approximately 5 percent of disequilibrium occurring in the system due to various shocks. The results of the ECM presented in Table 4 indicate that in the short run, all three independent variables are significant predictors of GDP, with both PMI and manufacturing output having a positive relationship with GDP. While CPI negatively affects economic growth. Similar results were also confirmed by Tsuchiya (2012) and Lindsay and Pavur (2005).

Table 4: Results of ECM and Short Run relationships

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LnCPI)	-0.1255	0.0450	-2.7831	0.0072*
D(LnPMI)	0.0171	0.0054	3.1578	0.0024*
D(LnMANU)	0.2221	0.0220	10.0940	0.0000*
CointEq(-1)	-0.0495	0.0044	-11.1456	0.0000*

Note: * significance level at 5%

The Granger causality test is also used to test the short-run and causal relationships amongst all variables. The test results are exhibited in Table 5. The main results indicate that LnPMI has bi-directional causality with both LnGDP and LnMANU, as also found by Lindsay and Pavur (2005), Chien and Morris (2016) and Aprigliano (2011). While a bi-directional causality exists between LnMANU and LnGDP. Lastly LnCPI only causes changes in LnMANU on the short-run.

Table 5: Granger causality results

Causality direction	p-value
LnMPI causes LnGDP	0.0338*
LnGDP causes LnPMI	0.0090*
LnMPI causes LnMANU	0.0458*
LnMANU causes LnPMI	0.0019*
LnMPI causes LnCPI	0.5649
LnCPI causes LnPMI	0.0857
LnMANU causes LnGDP	0.0016*
LnGDP causes LnMANU	0.0001*
LnGDP causes LnCPI	0.6692
LnCPI causes LnGDP	0.0054
LnMANU causes LnCPI	0.3675
LnCPI causes LnMANU	0.0002*

Note: * significance level at 5%

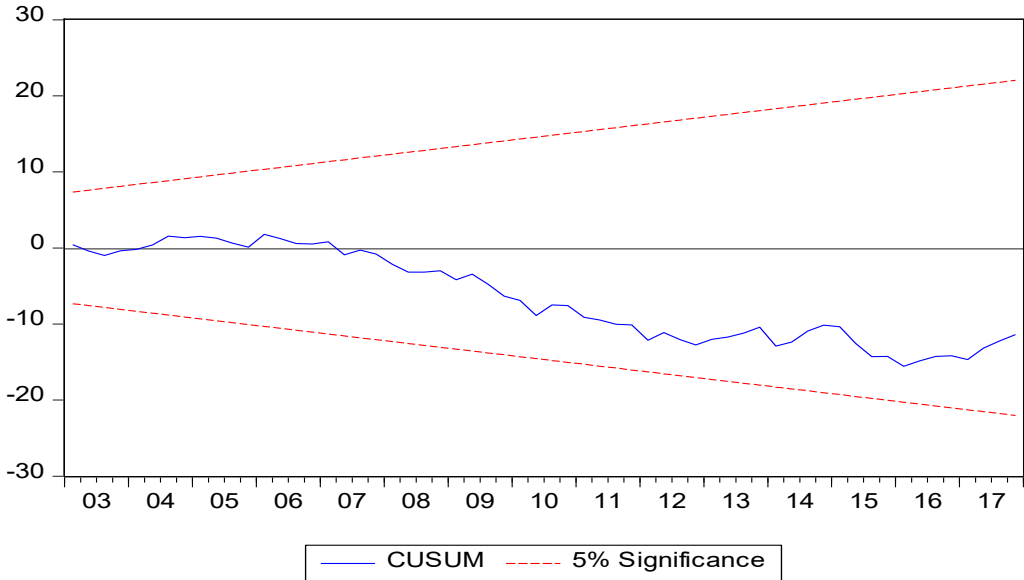
The results presented in Table 6 validate the reliability of the model. Using the White test, the obtained result affirms that variables are homoscedastic, while the Jarque-Bera test indicates that variables are normally distributed. Finally, the probability value of Ramsey RESET test supports the CUSUM test as indicated in Figure 3, suggesting the stability of the model used in the study.

Table 6: Results of statistical and diagnostic tests for ARDL Model

Test	F-statistics	Probability
Breusch-Godfrey Serial Correlation LM test		
Serial Correlation	0.0666	0.9356
White Heteroscedasticity Test		
Heteroscedasticity	0.3620	0.9001
Jarque-Bera test		
Normality	0.6157	0.7350

Figure 3 displays the graphical representation of the ARDL model stability test by means of the CUSUM test. Since the statistical plots remain within the critical bounds at 5 percent significant level, the null hypothesis suggesting that the model is stable, cannot be rejected.

Figure 3: CUSUM stability test



5. CONCLUSION

The primary objective of the study was to specifically analyse the value of the PMI and output in the manufacturing sector as predictors of GDP output, but also to test causality between all the included variables. Empirical results from the data analysis infer a short and long-run relationship between the variables included in the study: PMI, total output from the manufacturing sector, CPI and economic output (GDP). The total output from the manufacturing sector and PMI were found to have a positive impact on economic output, whilst the increase in CPI leads to a decline in economic output in both short and long-run. In addition to the short-run relationship obtained by estimating the ECM, the Granger causality indicates that changes in PMI and changes in manufacturing output cause short-run movement in economic output. If all three variables (independents) are compared, the output from the manufacturing sector is more likely to influence economic output than other variables. An interesting finding was that CPI has much less of an impact on both manufacturing and GDP output if compared to the PMI and there is no significant relationship between PMI and CPI. This implies that more focus should be placed on increasing the manufacturing sector output, which could lead to overall economic growth and employment creation, which should be the main priority for economic stakeholders and policy makers in South Africa. Future research will focus on adding other relevant variables, such as interest rates to the modelling. Lastly, in making economic decisions, the level of

PMI specifically as a leading indicator should be seen as a key predictor and early warning system for the manufacturing sector and GDP changes on both the short and long-run.

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