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Research article

Autoregressive distributed lag estimation of bank financing and Nigerian manufacturing sector capacity utilization

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Abstract: This study examined the short-term and long-term relationship between credit financing by commercial banks and capacity utilization of the manufacturing sector in Nigeria. The study employed both classical Multiple Linear Regression (OLS-MLR) and the autoregressive distributed lag model (ARDL) to analyze data representing the period 1981–2020 relating to sectoral credit finance, labor employment, and capacity utilization from the Central Bank of Nigeria Statistical Bulletin (2020) and World Bank Development Indicators (2021). Further, the two estimation procedures were performed within a classical endogenous Cobb-Douglas production function framework that takes technical change into consideration. The bounds test indicated no long-term relationship between bank financing and average capacity utilization of the manufacturing sector in Nigeria. However, the ARDL results revealed that bank financing exerts a positive but insignificant short-term impact on the average capacity utilization of the manufacturing sector in Nigeria. Consequently, the researchers affirm that credit financing by commercial banks in Nigeria has no significant impact on the capacity utilization of the country's manufacturing sector, in neither the short run nor the long run.

Keywords: commercial bank; credit; finance; capacity utilization; bounds test; ARDL model

JEL Codes: C39, G21, L60

1. Introduction

This study employs the autoregressive lag model (ARDL) to understand and evaluate the short-and long-run impacts of commercial bank financing on the capacity utilization of manufacturing companies in Nigeria. Understanding and evaluating the commercial bank financing function toward improved capacity utilization in the manufacturing sector is imperative. The finance-led growth hypothesis stresses that an efficient financial system tends to accelerate a country's economic growth (Alhassan et al., 2021). In developing economies, however, evidence suggests that manufacturing sectors face credit constraints from financial markets (e.g., banks) and this prevents the companies in these sectors from embarking upon high-valued investment in plant, machinery, and other inputs essential for optimization of their capacity utilization (Chen et al., 2017; Zhang, 2020). For instance, the average capacity utilizationof the manufacturing sector in Nigeria in 2020 was 45.2% (Nigerian Economic Summit Group (NESG), 2021), implying a low actual output rate compared to the expected level of production ifthe sector uses all available resources. The use of the ARDL approach in this study hinged on its advantages over alternative methods like vector autoregressive (VAR) and vector error correction models (VECM) for econometric analysis of short-term and long-term impacts. Such merits include flexibility for the unit roots pretest, parsimonious specifications, and exogenous treatment of all variables in the ARDL model (Nkoro & Uko, 2016; Rao, 2005).

In Nigeria, several studies have been conducted on industrial performance analysis of the manufacturing sector (Umofia, 2018; NESG, 2021; United Nations Development Program and the National Bureau of Statistics, 2021), industrial capacity utilization of the manufacturing sector (Omenyi, 2017), and the relationship between bank credit and growth in the manufacturing sector (Ademu et al., 2019; Iorember & Ebele, 2016; Gbadebo et al., 2017). Some studies have reported a long-term and positive relationship between bank credit and growth in the manufacturing industry in Nigeria. However, as the evidence suggests, most previous studies in this field have grossly ignored the nexus between bank credit financing and capacity utilization in the Nigerian manufacturing sector in both the short and the long run. Even in foreign studies in which the nexus between finance (credit or loan supply) and productivity has been examined, empirical evidence suggests that the main focus has been on the firms. Examples of studies in this regard include Zhang (2020) in Latin America, Manaresi and Pierrri (2018) in Italy, Amiti and Weinstein (2018) and Huber (2017) in Germany, Franklin et al. (2015) in the United Kingdom, and Gopinath et al. (2017) and Cette et al. (2016) in Europe. Meanwhile, a comprehensive analysis of the short- and long-termimpact of bank credit financing on the manufacturing sector could help inform output growth-oriented monetary policies of central banks that have national welfare benefits in both contemporaneous periods and the future. For instance, the lending hypothesis suggests that an appropriate monetary policy is key to the level of bank loan supply, which has a direct influence on output (Wang, 2001). Again, the production function model implies that abundant input resources like capital (e.g., bank loans) and labor can increase productivity if those resources are put to maximum use.

This study contributes to the existing literature in two ways. First, it provides empirical information on a specific link between bank financing and capacity utilization in the manufacturing sector of a developing country. By implication, it shows that access to finance has a direct effect on capacity utilization and an indirect influence on the performance of the manufacturing industry. Second, unprecedentedly, the study uses cognizance of technical changes in ARDL estimates. According to classical studies (Frazer, 2002; Handsaker & Douglas, 1937; Williams, 1945), failure to factor in technical change in a production function can lead to misspecification error. Therefore, the dynamism of the ARDL technique in this paper considers the time trend that captures technical changes in the Nigerian manufacturing sector for an appropriate model specification, which distinguishes this analysis from a conventional regression. In this study, the initial ordinary least square (OLS) model's outcome shows evidence of technical progress in productive installed plants and machinery in the Nigerian manufacturing industry. However, applying the bounds test found no long-term relationship between bank financing and average capacity utilization of the manufacturing sector in Nigeria. Again, a model re-evaluation with no labor factor in the Cobb-Douglas function as a robustness check further confirmed the absence of a long-term relationship. This implies that if there are shocks in the short run, they cannot affect movement in the individual time series, since they will not converge in the long run. On the other hand, evidence further reveals that bank financing exerts a positive but insignificant short-term impact on average capacity utilization in the manufacturing sector in Nigeria.

This study is organized as follows. Section one introduces the study, followed by a review of the relevant literature in section two. Section three discusses the methodology adopted to achieve the study objective, and section four reports, interprets, and discusses the results. The last part, section five, presents conclusions and recommendations.

2. Literature review

Conceptually, capacity utilization illustrates the extent to which a production firm uses its resources to achieve a certain output level. Specifically, capacity utilization in the manufacturing sector implies the share or percentage of the sector's actual output out of the industrial maximum output with all required resources present or available (Satik, 2017). Thus, capacity utilization determines the operational efficiency of production in the manufacturing or industrial sectors of the economy. By implication, an increase in capacity utilization means that the industrial sector achieves a higher actual output level relative to its maximum or expected level of production, and vice versa. The production efficiency indicator can be measured by expressing the manufacturing sector's actual output as a percentage of its potential or expected output. The result provides information on the state of production and the extent of resource utilization in manufacturing. Meanwhile, certain structural factors affect the capacity utilization of industrial companies, particularly in the manufacturing sector in developing countries like Nigeria. These factors include infrastructural factors such as power supply, transportation networks, and water supply (Omenyi, 2017; NESG, 2021); technological factors like advanced plants and machineries, information, communication, and technology (ICT) (Dutz et al., 2018; Omenyi, 2017; NESG, 2021); economic factors consisting of market demand, inflation rate, and exchange rate (Omenyi, 2017) and financial factors such as interest rate, nature of a country's financial market, and credit availability (Zhang, 2020).

In recent times, security challenges in Nigeria have further limited labor productivity in manufacturing and other sectors of the economy. Also, the structural shock from the global pandemic COVID-19 is another factor that is currently affecting capacity utilization in manufacturing and other businesses around the globe, including Nigeria. Within the context of the current study, much emphasis is placed on financial factors, particularly the financing of manufacturing companies in Nigeria by commercial banks in the country. The apex bank of the economy, like the Central Bank of Nigeria, through its monetary policy and economy management functions often directs commercial banks to streamline part of their credit functions to the manufacturing sector and other sectors of the economy. It is important to provide investment funds for these sectors in order to improve the economy. In Nigeria, for instance, a portion of commercial banks total credit, loans, and advances are specifically directed to the manufacturing sector. Although the funding comes with cost implications and high interest rates that may discourage a manufacturing company intending to borrow from such a source, credit extended to the manufacturing sector by commercial banks in Nigeria serves as a reliable source of funds for manufacturing companies to increase their capacity utilization of installed production plants and machinery.

Theoretically, the relationship between capacity utilization of the manufacturing sector and bank finance can be effectively understood within the Cobb-Douglas production function framework developed by Cobb and Douglas (1928). The model shows the relationship between production output and the inputs (capital and labor) employed to achieve such output. According to the Cobb-Douglas production function, the rate of output production is dependent on the responsiveness or elasticity of output to rate changes in capital and labor as production factors, respectively. Complementarily, the outcome of capacity utilization in the manufacturing sector in this study can be observed as an elasticity of capacity utilization to the rate of bank financial resources available to the industry. This view has been upheld by Ganau (2016), who says that the level of capital and labor inputs available in a firm affect its rate of capacity utilization. Although Cecchetti and Kharrroubi (2015) observed a negative correlation between growth in the financial sector and total factor productivity growth in the manufacturing sector among some selected advanced OECD economies through OLS estimation, the Cobb-Douglas production model can reveal the extent or degree of relationship between financial resources from banks and the rate of capacity utilization by manufacturing sectors in developing economies like Nigeria.

Empirically, the outcome of Cecchetti and Kharrroubi (2015) implies that in developed countries there is a negative correlation between financial sector growth and productivity in the manufacturing sector, particularly when more bank credit facilities are channeled to low-productivity and/or high-collateral-endowed firms. In developing countries, Zhang (2020) evaluates the relationship between credit constraint and capacity utilization of manufacturing sectors in six selected Latin American nations, which include Argentina, Bolivia, Ecuador, Paraguay, Peru, and Uruguay. In this study by Zhang, credit-constrained private manufacturing firms experienced lower capacity utilization than non-credit-constrained firms. Again, several empirical studies have been conducted on the importance of bank financing to the manufacturing sector, particularly on the growth of the manufacturing industry in Nigeria. Examples of these studies, among others in this regard, include Ademu et al. (2019); Ogbonna (2018); Okunade (2018); Iorember and Ebele (2016); and Gbadebo et al. (2017).

In reference to Ogbonna (2018), who analyzed the relationship between bank funding and the growth of the manufacturing sector in Nigeria, there is a bidirectional relationship between the two economic series, and the impact of bank funding on the output of the manufacturing sector is limited in time. Ogbonna arrived at such findings by employing ARDL and factor analysis approaches. The ARDL technique was also employed by Okunade (2018) to analyze the impact of capacity utilization on manufacturing production, with evidence suggesting an insignificant positive impact. Similarly, Ademu et al. (2019) observed a long-run relationship between bank credit and the growth of the manufacturing industry in Nigeria through analysis of data drawn from the two economic series from 1986 to 2017 using a non-linear autoregressive distributed lag model (NARDL) as an estimation technique. Meanwhile, the same result was earlier obtained by Iorember and Ebele (2016) and Gbadebo et al. (2017). In Gbadebo et al. (2017), an empirical attempt was made to analyze the relationship between bank loans and advance facilities and the growth of the manufacturing sector in Nigeria from 1978 to 2015, employing the Error Correction Model (ECM). Similarly, the trend analysis of the performance of the agriculture sector and industrial capacity utilization in Nigeria had also previously been carried out by Umofia (2019), Omenyi (2017), and in more recent times by NESG (2021), the United Nations Development Programme, and the National Bureau of Statistics (UNDP and NBS, 2021). These studies point to a fall in manufacturing capacity utilization, which consequently causes a decline in real manufacturing output. According to NESG (2021), UNDP and NBS (2021), the decline in capacity utilization of the manufacturing sector in Nigeria is principally caused by structural challenges such as the business environment (including funding by banks) and the recent global pandemic COVID-19. However, as the evidence suggests, most of the previous studies in this field have overlooked the specific relationship between bank credit financing and capacity utilization of the Nigerian manufacturing sector at both short-run and long-run levels.

3. Materials and methods

This study employs an ex post facto research design. The quantitative ex post-facto research strategy allows for testing the causal effect of predictors on outcomes of interest that have occurred prior to the current research (Saka & Aladelusi, 2022; Saka, 2021; Saka & Fatogun, 2021; Wooldridge, 2001). In this manner, the adopted design enables the researchers to infer the causal effect of bank financing on prior capacity utilization of manufacturing sector installed plants and machinery. Since the study aimed at filling the void as earlier identified in the introductory part, the population of the study consists of all sub-sectors of the manufacturing sector in Nigeria. According to the statistics made available by CBN in 2020, there are currently 48 sub-sectors in the Nigerian manufacturing industry. Consequently, this number (48) is taken as the final population of the study, and with the use of aggregate data over all these subsectors the sampling process becomes meaningless or non-essential. In the main, the empirical model formulated for the study is developed within the theoretical background of an endogenous Cobb-Douglas production function proposed by Douglas and Cobb (1928) and further calibrated with the introduction of technical change into the model. As stated in the literature review section, the model shows the relationship between production output and the inputs (capital and labor) employed to achieve such output. It seems plausible to introduce technical change because failure to consider such productivity factors could lead to misspecification errors (Frazer, 2002; Handsaker & Douglas, 1937; Williams, 1945). Here, the input is measured by financial resources (in this case, loans and advances) provided by banks, and the output is observed to be the rate of capacity utilization by the manufacturing sector in Nigeria. Also, additional input like labour is added to the model in order to complete the properties of the Cobb-Douglas production function. Following the International Labour Organization (ILO), the data on labour represents employment in the manufacturing sector as a percentage of total employment. The original Cobb-Douglas production function is stated as follows:

$$Y = A\,(t) L^{\beta_\propto} K^{1-\beta_\propto} \tag{1}$$

where Y = Output; A = Constant technology; L = labour; K = Capital; $\beta_\propto$ and $1 - \beta_\propto$ are the coefficients of the input factors (L and K). The Equation 1 assumes a constant return to scales for both inputs in the Equation.

Consistent with the Cobb-Douglas production model, the study model is developed as follows:

$$Capacity\ Utilization = f\ (Bank\ Financing)$$
$$ACP_t = \alpha + \beta_1 CRM_t + \beta_2 MNE_t + \varepsilon_t \tag{2}$$

A time trend (T) indicator is further included in Equation 3 to account for technical change in Equation 1. This practice is consistent with Fraser (2002). Equation 3 is formulated as:

$$ACP_t = \alpha + \varphi T + \beta_1 CRM_t + \beta_2 MNE_t + \varepsilon_t \tag{3}$$

The logarithm value (to the nearest tenth figure) of CRM was taken to be at the same measurement level with employment variable, MNE. Such econometric treatment allows coefficients of the predictors, β_1 and β_2, to be treated as elasticities which can be used to assess constant return scale (CRS) assumption of production function model through testing of hypothesis on the sum of the predictor coefficients. This procedure transforms Equation 3 into Equation 4.

$$ACP_t = \alpha + \varphi T + \beta_1 LNCRM_t + \beta_2 MNE_t + \varepsilon_t \tag{4}$$

Equation 4 which is consistent with model employed in Saka and Adebesin (2021) serves as a long-run model in the current study. From Equation 4, *ACP* = Average Capacity Utilization; *T* = time trend; *CRM* = Commercial Banks' Credit to Manufacturing Sector; *MNE* = Employment in the manufacturing sector; β_1 = coefficient of *LNCRM*; β_2 = coefficient of *MNE*; α = intercept value; ε = error term; t = year, ranging from 1...........40; The indicator, φ, measures the proportionate change in capacity utilisation of manufacturing sector in Nigeria due to technological progress.

Further, the endogenous growth model in Equation 4 was transformed into ARDL model as:

$$ACP_t = \alpha + ACP_{t-1} + \varphi T + \beta_3 LNCRM_{t-1} + \beta_4 MNE_{t-1} + \sum_{j=1}^{p} \pi_j ACP_{t-j} + \sum_{j=0}^{q_1} \gamma^1{}_j T_{t-j} + \sum_{j=0}^{q_2} \gamma^2{}_j LNCRM_{t-j} + \sum_{j=0}^{q_3} \gamma^3{}_j MNE_{t-j} + \varepsilon_t \tag{5}$$

It is expected through the estimation procedure that ACP_t is cointegrated with the predictors (T,$LNCRM_t$, and MNE_t) in the study. If that is the case, then Equation 5 can be re-written as:

$$\Delta ACP_t = \alpha + \sum_{j=1}^{p} \pi_j \Delta ACP_{t-j} + \sum_{j=0}^{q_1} \gamma^1{}_j \Delta T_{t-j} + \sum_{j=0}^{q_2} \gamma^2{}_j \Delta LNCRM_{t-j} + \sum_{j=0}^{q_3} \gamma^3{}_j \Delta MNE_{t-j} + \delta u_{t-1} + \varepsilon_t \tag{6}$$

The statistic index, δu_{t-1} in Equation 6 captures error correction mechanism. The Equation 5 and Equation 6 as written in this study are consistent with the practice in Cho, Greenwood-Nimmo and Shin (2020).

Should T in Equation 6 causes linearity problem then the time trend series will be dropped in Equation 6 and re-parameterized in Equation 7 as:

$$\Delta ACP_t = \alpha + \sum_{j=1}^{p} \pi_j \Delta ACP_{t-j} + \sum_{j=0}^{q_4} \gamma^4{}_j \Delta LNCRM_{t-j} + \sum_{j=0}^{q_5} \gamma^5{}_j \Delta MNE_{t-j} + \delta u_{t-1} + \varepsilon_t \tag{7}$$

where $u_{t-1} = (ACP_{t-1} - \gamma^0 - \gamma^4 LNCRM_{t-1} - \gamma^5 MNE_{t-1})$.

However, Equation 4 was run to account for technical change effect in the long-run. Finally, Equation 7 is estimated with ARDL (Bound Testing) technique at 5 % level of significance using STATA 12 as statistical software. The data for the study were obtained from Central Bank of Nigeria (CBN) Statistical Bulletin (2020) and World Bank Development Indicators (WDI, 2021).

4. Results and discussion

4.1. Presentation of results

This sub-section displays the estimation outcomes of the analyses conducted using the study data. The outcomes of the estimation procedures are revealed in the following tables:

Table 1. Lag length selection criteria.

Sample:1995–2019; Number of obs=25								
Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	−165.07		16		8.79559	13.5256	13.5797	13.7206
1	758.315	1846.8*	16	0.000	1.1e−30	−59.0652*	−58.7947*	−58.0901*
2	754.047	−8.5352	16		8.2e−30	−57.7638	−57.3311	−56.2036
3	742.448	−23.199	16		2.7e−31	−55.8758	−55.2808	−53.7306
4	740.713	−3.4689	16		3.4e−29	−54.7771	−54.0198	−52.0468

Note: * implies the most suitable lag length.

Source: STATA Outputs, 2022.

Table 2. Bounds test result.

Measure at 5% Significance Level	Critical Value	Remark
I (0)	3.79	Level
I (1)	4.85	First Difference
F-Statistic	3.56	No co-integration

Note: The order of cointegration means that critical values of series are higher than upper limit of ADF statistics at 5% level of significance.

Source: Extracts from STATA Outputs, 2022.

Table 3. Standard OLS and ARDL model estimation results.

Variable	Standard OLS			ARDL Model (Short-run Impact)		
	Coeff.	Std. Error	P>|t|	Coeff.	Std. Error	P>|t|
ACP L1. T	2.827	0.705	0.000*	0.471	0.167	0.009*
LNCRM	−13.025	4.144	0.004*	1.449	1.187	0.234
MNE	−6.959	1.779	0.001*	−2.444	1.758	0.177

Note: * implies significance at 5% level*.

Source: Extracts from STATA 12 Outputs, 2022.

Table 4. Post diagnostics tests (ARDL Model).

Measure	Statistic	Chi2	H_0	Remark
Autocorrelation	Breusch-Godfrey LM Test	0.0523	No Autocorrelation	Accept
Heteroscedasticity	White Test	0.2932	Homoscedasticity	Accept

Note: The p-values of chi2 are higher than the study adopted 5% level of significance

Source: Source: Extracts from STATA Outputs, 2022.

4.2. Interpretation of results

The pre-test unit root analysis through the Augmented Dickey-Fuller statistic (Note 1: Appendix) illustrates that the main variables of interest in this study, such as *ACP* and *CRM,* are found to be stationary at levels, that is, at level 0. The results show that the p-values for the two series call for rejection of the null hypothesis that these two variables have a unit root. Again, in absolute values, the test statistic for both *ACP* and *CRM* was greater than the interpolated Dickey-Fuller critical values at the 5% level of significance. By implication, there is an indication of possible co-integration between the two economic series. On the contrary, the other two variables, like *T* and *MNE,* are assumed not to have unit root characteristics. This is because *T* represents a time trend, which is not directly measurable, while *MNE* possesses just a 2-digit figure in percentage as obtained from the data source. Further, in order to run *ARDL* model estimation, the lag selection process was conducted using three different information criteria, which are Akaike Information Criteria *(AIC),* Hannan-Quinn Information Criteria *(HQIC),* and Schwarz Information Criteria *(SIC)* in STATA 12. However, the convention is that the information criteria with the lowest value are chosen to inform the selection of the appropriate number of lags or lag length selection (Cameron and Trivedi, 2009; Gujarati, 2004). The outcome in Table 1 shows that, despite the fact that AIC is most preferable because it produces the least value, other information criteria still give lag (1) as the appropriate lag length. In fact, the result is consistent with a previous finding by Liew (2004) that *AIC* should be employed for small observations that are below 60. Lie postulates further that the *AIC,* along with the Final Prediction Error *(FPE),* usually performs better than other lagged selection criteria for small samples. For individual series, appropriate lag selection was obtained through matrix listing in the *ARDL* estimation procedure in STATA 12 for the three final variables, which are *ACP, LNCRM, and MNE* (lag length: 100).

In addition, the estimation of Equation 6 displays a situation of collinearity caused by *T* (time trend), and as a result, the variable T was dropped in the advanced ARDL procedure. Therefore, the OLS technique was used to account for the effect of technical change on the average capacity utilization of the manufacturing sector in Nigeria, after which the ARDL estimation process followed. Subsequently, Equations 4 and 7 were simultaneously run, as earlier stated in the methodology section. Prior to this stage, the *Bounds Test* by Pesaran et al. (2001) was performed to determine the existence of a long-run relationship or co-integration property among the variables. The result of the *bounds test* estimation, as revealed in Table 2 and Table A.6 in the Appendix, shows the absence of a long-run relationship among the series. This is premised on the rejection of the null hypothesis of no-cointegration as *F-Statistics* calculated falls below the critical value for the lower bound *I (0)* at a 5% level of significance. Afterwards, a short-run impact estimation of commercial bank financing on capacity utilisation of the manufacturing sector in Nigeria was performed, having discovered the absence of a long-run relationship. The short-run evaluation result along with the standard *OLS* outcome are contained in Table 3. In Table 3, it is shown that the time trend (*represented by T*) has a significant positive impact (*2.827: p-value < 0.05*) on the average capacity utilization of the manufacturing sector in Nigeria. This implies that, for an improved technical change, the average capacity utilization of manufacturing firms in Nigeria would significantly increase by 2.87% every year. On the other hand, the standard *OLS* (Table A.1, Appendix) depicts significant negative effects of increased bank financing (*−13.025: p-value < 0.05*) and more labour employment (*−6.959: p-value < 0.05*) on average capacity utilization of the manufacturing sector in Nigeria.

However, in recognition of the shortcoming of *OLS* in analyzing non-stationary data in a time series analysis, the study considers the negative effects produced by bank financing activities and labor employment on the average capacity utilization of the Nigerian manufacturing sector as biased and unreliable estimates (Shrestha & Bhatta, 2017). In other words, a robust technique that allows estimation of both stationary and non-stationary data in a single time series study, such as the *ARDL* technique, is adopted. The result of the *ARDL* estimation is also contained in Table 3 (the full estimation result is in Table A.6 in the Appendix). The *ARDL* estimation illustrates that the immediate past value (*Lag 1*) of average capacity utilization of the manufacturing sector in Nigeria significantly and positively affects the current value of the industry's average capacity utilization. That is, a percentage point change in the first lag of average capacity utilization in the industrial sector in Nigeria is significantly associated with a 0.47% increase in the sector's average capacity utilization, on average, *ceteris paribus at the* 1% level of statistical significance. Commercial bank financing activities for the benefit of the manufacturing sector in Nigeria produce a positive short-run impact on the average capacity utilization of the sector; however, such an impact is found to be insignificant. The ARDL results show further that, in the short run, an increase in labour employment in the manufacturing industry leads to a fall in the sector's average capacity utilization of 2.44%. However, both the increased bank lending to the manufacturing sector in Nigeria and the increased employment in the industry are found to be statistically insignificant in the short run. Interestingly, important tests for violation of assumptions of *ARDL* under which estimations become unreliable were conducted, and those assumptions are statistically fulfilled. These tests include autocorrelation and heteroscedasticity. The outcomes in Table 4 show the acceptance of the null hypotheses of no autocorrelation (*p-value >0.05*) through the *Breusch-Godfrey LM Test* (Table A.8, Appendix) and homoscedasticity (*p-value > 0.05*) the Nigerian manufacturing sector as biased and unreliable estimates (Shrestha & Bhatta, 2017). In other words, a robust technique that allows estimation of both stationary and non-stationary data in a single time series study, such as the ARDL technique, is adopted. The result of the ARDL estimation is also contained in Table 3 (the full estimation result is in Table A.6 in the Appendix).

The ARDL estimation illustrates that the immediate past value (Lag 1) of average capacity utilization of the manufacturing sector in Nigeria significantly and positively affects the current value of the industry's average capacity utilization. That is, a percentage point change in the first lag of average capacity utilization in the industrial sector in Nigeria is significantly associated with a 0.47% increase in the sector's average capacity utilization, on average, ceteris paribus at the 1% level of statistical significance. Commercial bank financing activities for the benefit of the manufacturing sector in Nigeria produce a positive short-run impact on the average capacity utilization of the sector; however, such an impact is found to be insignificant. The ARDL results show further that, in the short run, an increase in labour employment in the manufacturing industry leads to a fall in the sector's average capacity utilization of 2.44%. However, both the increased bank lending to the manufacturing sector in Nigeria and the increased employment in the industry are found to be statistically insignificant in the short run. Interestingly, important tests for violation of assumptions of ARDL under which estimations become unreliable were conducted, and those assumptions are statistically fulfilled. These tests include autocorrelation and heteroscedasticity. The outcomes in Table 4 show the acceptance of null hypotheses of no autocorrelation (*p-value > 0.05*) through the Breusch-Godfrey LM Test (Table A.8, Appendix) and homoscedasticity (*p-value > 0.05*) through the White Test (Table A.9, Appendix) of error variance over time. Also, the model stability test through the *CUSUM* graph in STATA 12 (Fig. A.1, Appendix) indicates that the model is stable, having found the graph to lie within a 5% boundary, and again satisfies the overall goodness of fit condition via the probability value of the *ARDL* model *F-statistic* (*p-value < 0.05 = 0.0000*).

4.3. Discussion of results

The study examines the short-run and long-run relationship between credit financing by commercial banks and capacity utilization of installed plants and machinery in the manufacturing sector for a period ranging from 1981 to 2020. Estimation outcomes show that the *OLS* and *ARDL* models employed in the study are good enough and adequate to explain such relationships. Specifically, important assumptions of the *ARDL* technique, such as the absence of serial autocorrelation, homoscedasticity, and model stability, were tested and found not to be violated. According to *OLS* analysis, technical change positively influences the average capacity utilization of manufacturing firms in Nigeria. This implies that improvements in technologies adopted by manufacturing companies in the country bring about a significant and positive increase in their average capacity utilization rate over time. Meanwhile, the *ARDL* technique was employed to analyze the effect of commercial bank financing due to the shortcoming of *OLS* in analyzing non-stationary time series. However, the result is an absence of co-integration between credit financing by commercial banks and manufacturing firms' average capacity utilization in Nigeria. A model re-evaluation approach with no labour factor in the Cobb-Douglas function as a robustness check further confirms the absence of a long-run relationship. This connotes that commercial bank financing has no long-run relationship with the sector's average utilization capacity and that economic forces cannot bring the two series into equilibrium when they drift apart in the long run.

More surprisingly, the *ARDL* model which is a short-run analysis estimation procedure shows that only *Lag (1)* of average capacity utilization significantly increases average capacity utilization for manufacturing companies in Nigeria. In contrast, the main variable of interest (that is, commercial banks' credit to the manufacturing sector) produces a non-significant short-run positive impact. The implication of this finding is that, in the short run, lending by commercial banks to manufacturing firms in Nigeria has a positive impact on the average capacity utilization rate of the industry. However, such a short-run positive impact is found to be statistically insignificant. The evidence of the short-run positive impact of bank lending on the average capacity utilization rate of the manufacturing industry in Nigeria is consistent with the postulations of the endogenous growth model employed in this study. But why the observed short-run impact was found to be statistically insignificant can be associated, in part, with the small effect size of the study's main predictor coefficient ($LNCRM \cong 1.45\%$) and coupled with the possibility that some manufacturing firms in developing countries like Nigeria face credit constraints from commercial banks (Zhang, 2020). More unfortunately, economic data on the level of credit constraints faced by manufacturing firms in Nigeria is largely unavailable. Even so, not all manufacturing firms currently operating in the country are effectively covered in the CBN Statistical Bulletin, which is the main source of the data for the study. In addition, the findings of the study are consistent with previous studies such as Omenyi (2017) in Nigeria; Zhang (2020) in Latin America; Manaresi and Pierrri (2018) in Italy; Amiti and Weinstein (2018); Huber (2017) in Germany; Franklin et al. (2015) in the United Kingdom; Gopinath et al. (2017); and Cette et al. (2016) in Europe. According to Zhang, firms that face credit constraints in Latin America experience lower capacity utilization. Moreover, the finding of a positive impact of technical change on average capacity utilization rate is in line with Frazer (2002), Handsaker and Douglas (1937), and Williams (1945), all of which were conducted in the United States of America.

5. Conclusions

This study examines the short-run and long-run relationship between credit financing by commercial banks and capacity utilization of installed plants and machinery in the manufacturing sector for a period ranging from 1981 to 2020 within the endogenous Cobb-Douglas production function framework. The outcome shows evidence of technical progress in the productively installed plants and machinery in Nigeria's manufacturing industry. But no long-run relationship was obtained between bank financing and average capacity utilization in the manufacturing sector in Nigeria. This implies that if there are shocks in the short run, such shocks cannot affect movement in the individual time series (bank financing and average capacity utilization) since they will not converge in the long run. On the other hand, evidence reveals further that bank financing exerts a positive but insignificant short-run impact on the average capacity utilization of the manufacturing sector in Nigeria. The researchers affirm, therefore, that credit financing by commercial banks in Nigeria produces no significant impact on the capacity utilization of the country's manufacturing sector both in the short-run and the long-run. The study recommends that commercial banks in Nigeria re-consider their lending requirements to manufacturing firms in the country for bank lending to produce the desired results on capacity utilization in the sector. More importantly, the Federal Government, through CBN, needs to establish a bespoke funding mechanism for the manufacturing sector in the country.

In retrospect, the outcome of the traditional ARDL approach in this study shows that the time series employed cannot be linearly combined as there is no evidence of a long-run relationship. An alternative approach like the non-linear autoregressive distributed lag (NARDL) model could possibly reveal co-integration among the series. Again, reliable and efficient data that not only cover a sufficient number of manufacturing firms in Nigeria but also distinguish low-credit-constraint firms from more credit-constrained ones is needed for an effective future examination of the impacts of financing activities by commercial banks on the average capacity utilization of the manufacturing sector in Nigeria.

Conflict of Interest

All authors declare no conflicts of interest in this paper.

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