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Research article

Tractor acquisition and agricultural performance among Nigerian farmers: Evidence from Co-integration Modeling technique

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A R T I C L E I N F O

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A B S T R A C T

Given the envisioned significance of the agricultural sector in Nigeria, which scholars have argued has the potential to promote pro-poor growth and poverty alleviation. However, questions have been raised about using and accessing modern agricultural machinery for farm cultivation. In this regard, this study uses a co-integration modelling technique to investigate the impact of tractor acquisition on agricultural performance. Two equations were established through the normalisation processes to proxy agricultural performance: the agricultural output and employment equations. Firstly, the analysis procedure requires a preliminary test to determine the statistical properties of the series used in this study; evidence from the outcome indicates that the series are not stationarity at level form and are integrated of order one. Secondly, based on the outcome of the preliminary result, the error correction model approach to co-integration was adopted, which helps to capture the short-term dynamics and long-term equilibrium of the effect of tractor acquisition on agricultural output and employment. The findings from the agricultural output equation show that credit to the agricultural sector, land cultivated for agricultural purposes, and tractor acquisition are statistically significant contributors to agricultural output. The agricultural employment equation shows that credit to agricultural purposes, land cultivated for agriculture and rainfall have a positive long-term relationship with employment. At the same time, tractor acquisition has a negative impact on agricultural employment in the long run. In the short run, exchange rate, rainfall, and tractor acquisition positively correlate with agricultural employment. In contrast, credit for agricultural purposes and land cultivated for agriculture negatively affects employment. Based on the findings, there is a need to strengthen policies that support access to credit, promote sustainable land use practices, and enhance water management. Also, policymakers should consider implementing measures that encourage the adoption of tractor technology while simultaneously addressing potential challenges related to job displacement.

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1. Introduction

Agriculture is fundamental to the socio-cultural and economic well-being of Nigerians. A vehicle for reducing hunger, alleviating poverty, economic emancipation, and restoration of human dignity. The hub services agro-based industries are the second-largest source of foreign exchange revenue after the oil sector. However, scholars have stressed that for Nigerian farmers to reap these benefits, agriculture must be transformed from a subsistence venture to a profitable commercial enterprise; this is critical and will serve as a potent force that stimulates development and long-term economic growth [1–3]. Nigeria's diverse range of agroecological zones helps to produce different agricultural products. Despite this rich endowment of agro-based resources, the sector has witnessed stunted growth; this is evident as less than half of the cultivable or arable lands are engaged for agriculture, mostly at the subsistence level using primitive tools with attendant drudgery and low yield [4–7]. Likewise, the issue of food insecurity persists, compounded by the enduring challenge of low economic capacity among farmers; the contribution of agriculture to aggregate welfare has recorded little effect [4,8–12]. With the agricultural sector's substantial contributions to gross domestic product (GDP) and its potential for employment generation, it is imperative to emphasise that adequate investment can boost growth and development in the long run. Infusing necessary financial resources into agriculture may also propel sectoral development and overall economic prosperity [2,13].

The advent of farm tractors has revolutionised agricultural practices as their applications cut across all facets of farm production, such as land clearing and tillage operations, to the movement of finished products to the market. It has helped to minimise food wastage and farm production costs by supplying the cheap farm power required along production processes [10]; this has led to the emergence of allied machinery that has assisted in value chain addition to agricultural products [14]. Access to or ownership of this vital machinery is one of the indices defining an economic level of mechanisation. Agricultural production has many problems, such as increasing energy costs and shrinking access to capital for farm machinery acquisition [15]. In addition to the rising environmental concerns due to land degradation, climate change effects, and other socio-economic factors that affect economic performance, the stakeholders in agribusiness have been striving to subdue these challenges to spur agri-productivity. Agricultural machines as a dynamic industry will continue to evolve to meet the changing needs of production agriculture [9,16]; this is significant as a robust agro-based power source is germane to the sustainability of the modern-day farming ecosystem.

The Nigerian farming community is burdened with continuous toilage and indignity, characterised by drudgery, physical stress, and an ageing farming population [17]. This is solely due to the low level of mechanisation as farm power is mostly supplied by human and animal-using crude implements thereby limiting the cultivable arable land acreage and overall productivity of the farmers [11,18]. The results are not far-fetched as, despite more than 70 % of the Nigerian labour force being engaged in agriculture, output is not commensurate with invested efforts into production. The introduction of farm machinery has made farming more appealing and acceptable, providing prospects for using higher intelligence, skills, experience, and initiative that enlightened men often possess, thereby promoting the dignity of the farming community [19].

Farm tractor availability and ease of access by the farmers are fundamental to achieving mechanisation benefits. Still, available information shows that Nigeria is far behind in attaining the needed satisfaction regarding the numbers of tractor power density and service life available to serve the vast farming community [20]. Due to some factors, there has been a decline in farmers' capacity to acquire tractors and other farm machinery. Key among them is the capital base of the farming community to acquire these machinery. Identifying and isolating these influencing success factors and building indicators that reflect the performance of established indices and their interactions with the principal or response variable is necessary, as lucid mechanisation policies can be based on this empirical information. This is evident as the access to viable and useable data has always been a limiting factor to making an informed decision and farm machinery policy.

In crop production, for a booty harvest, the land must be tilled, crop sown and tendered to maturity, harvested, processed, stored, and transported. These required energy inputs in which the tractor is at the centre, and hence its accessibility to the farmers must be supported for a robust, lucrative, and sustained agripreneurship [21]. Access to mechanical farm power such as tractors has always been a challenge to Nigerian farmers, especially at peak periods, because of the limited numbers available to serve or service the vast community of farmers. There have been concerted efforts over the years by various stakeholders towards easing the farmers' burden with little success recorded as the current number available is far below the required that can propel the country towards achieving the sustainable development goals of zero hunger, no poverty, responsible consumption and sustainable forms of environmental management. The need to examine indicators that govern investment in tractor acquisitions, access to its usage among Nigerian farmers and productivity in agricultural performance or output is imperative because of the huge socio-economic impacts. Many studies have established a direct link between agricultural performance and agribusiness development, economic growth, and sustainability [19–24]. Therefore, the main objective of this study is to investigate the impact of tractor acquisition on agri-performance in Nigeria. The specific objectives are as follows.

i. To examine the short and long-run impact of tractor acquisition on agricultural output.
ii. To investigate the short and long-run impact of tractor acquisition on agricultural employment.

The study uses the co-integration approach outlined by Engle and Granger to achieve these objectives. Use of this approach allows the study to examine the dynamic relationship between tractor acquisition and agricultural productivity in Nigeria.

2. Research Methodology

This study investigates the impact of tractor acquisition on agricultural performance in Nigeria. For this study to achieve its objective, two equations are established through the normalisation processes, which will be referred to as the agricultural output and employment equations. Firstly, the analysis procedure requires a preliminary test to determine the statistical properties of the series used in this study (the correlation test, descriptive statistics, Johansen co-integration and unit root test). Secondly, using the error correction model approach to co-integration to investigate the short-term dynamics and long-term equilibrium of the effect of tractor acquisition on agricultural output and employment. To better understand the concept, model specification, estimation techniques, data sources and measurements were elucidated sequentially in this section.

2.1. Model specification

The study uses the output theory as the theoretical framework. The strength of this framework lies in the capability to show the relationship between inputs used in producing output. Also, it reveals how changes in input variables impact overall output levels; this has been the standard approach used in output and productivity studies [4,23,24].

This theory assumes that inputs are needed to produce a given output (Eqn. (1)).

$$Y = f(x) \tag{1}$$

In equation (1), Y is the output, and x is the input. The explicit function of equation (1) can be written as:

$$Y = \alpha_0 + \alpha_1 x \tag{2}$$

In equation (2), α_0 is the constant term or the intercept while α_1 shows the slope or gradient of the equation. To achieve the specific objectives of this study, which are to examine the short-run and long-run impacts of tractor acquisition on agricultural performance in Nigeria. The agricultural performance is proxy by aggregate employment in the agricultural sector or farming population and total output produced by the agricultural sector. The output model stated that capital and employment are essential to production in agriculture. So, equation (2) was modified as follows:

$$Y_t = \alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 \tag{3}$$

From Equation (3), x_1 is the capital input while x_2 is the labour or employment inputs. Y in equation (3), according to the growth model, shows the aggregate output in a given country. This study focuses on the agricultural sector, so the study re-defines the variables as follows:

$$AO_t = \alpha_0 + \alpha_1 CA + \alpha_2 LA \tag{4}$$

In equation (4), AO, CA and LA represent agricultural output, capital in the agricultural sector and labour in the agricultural sector, respectively. Also, factors such as land and rainfall are important variables to be considered in producing agricultural products. Likewise, tractor acquisition is important in large-scale or mechanised production. Therefore, with the inclusion of other inputs, equation (4) becomes:

$$AO_t = \alpha_0 + \alpha_1 CA + \alpha_2 LA + \alpha_3 RF + \alpha_4 LD + \alpha_5 TQ \tag{5}$$

In equation (5), RF is the total amount of rainfall, LD is the land used for agricultural production, and TQ is tractor acquisition. Due to the effect of external factors from international trade, since most agricultural machinery is imported into the country, the exchange rate is also added to the variables, then equation (5) is modified and presented as equation (6):

$$AO_t = \alpha_0 + \alpha_1 CA + \alpha_2 LA + \alpha_3 RF + \alpha_4 LD + \alpha_5 TQ + \alpha_6 EX \tag{6}$$

Where EX is the exchange rate and other variables as earlier defined, to estimate the above equation, the error term is included to capture the effects of other factors that cannot be generalised due to minimised impacts on the model. In addition, minimising the error term will help to estimate the values for the parameters of the respective variables.

$$AO_t = \alpha_0 + \alpha_1 CA + \alpha_2 LA + \alpha_3 RF + \alpha_4 LD + \alpha_5 TQ + \alpha_6 EX + \mu_t \tag{7}$$

The error term μ_t is included in equation (7), which makes it an econometric model. The study carried out preliminary analyses such as the unit root and co-integration. Further explanation of these was given in the following subsections. The outcome of the co-integration result presented in the results and discussion section shows that the series has two co-integrating vectors. Because of this, two equations were generated to represent the output and employment in the agricultural section, while the tractor acquisition effect is captured as an independent or response variable in both equations.

This study uses the error correction model approach to co-integration; this estimation technique benefits the study by allowing it to capture the short-term dynamics of the effect of tractor acquisition on agricultural productivity in Nigeria. Also, it shows the long-term equilibrium between the dependent and independent variables. The ECM gives the error correction term, which measures the speed of adjustment from the short-run deviation to the long-run equilibrium. This is particularly useful in understanding the interplay between tractor acquisition and agricultural performance, and the procedure outlined by ECM gives it an advantage over other co-integration approaches by its ability to allow this study assess how farmers' actions in response to deviations influence the long-term equilibrium. Finally, employing ECM in this study, due to its flexibility, gives it a more nuanced perspective on the causal relationships between the dependent variable, which is agricultural output and other independent variables, which include tractor acquisition, and this enhances the accuracy of the analysis and gives valuable insights which make by crucial for policymakers and stakeholders in Nigerian agriculture.

2.2. Techniques of estimation

Naturally, unit root is a common problem in time series analysis. Using series that are not stationary will give spurious results, which can typify a wrong signal. Therefore, carrying out the unit root is imperative before estimating time series data. More so, it helps to determine the appropriate approach to use in estimation. There are several ways to test for the stationarity property of the time series. However, this study uses the Augmented Dickey-Fuller approach (ADF) that helped to establish a technique for determining the order of integration of the series [22]. The ADF equation is given in Eqn. (8) as:

$$\Delta M_t = \beta_0 + \beta_1 M_{t-1} + \varphi + \sum_{i=1}^{n} K_1 \Delta M_{t-k} + \varepsilon_t \tag{8}$$

In Equation (8), M_t represents the respective time series used in this study, φ is the linear trend while β_0 is the intercept and ε_t is the error term. Δ shows the differenced form. The null hypothesis is that the series is not stationary, while the alternative hypothesis is that the series is stationary using a 5 % significance level. If the null hypothesis is not rejected, the difference form will be considered, which is integrated of order one (1). If all the series are integrated of the same order, let's assume integrated of order one; then there is a tendency for the series to be co-integrated. The Johansen approach of co-integration was used in this study; this is used to test co-integrating relationships between several non-stationary time series data, allowing for more than one co-integrating relationship. The Johansen approach is only used to determine the number(s) of co-integrating vectors; two statistics were presented: the trace and the maximum Eigenvalue statistics. The Error Correction Model (ECM), also known as the Engel Granger approach to co-integration, was used to estimate tractor acquisition's short- and long-term effects on agricultural performance in Nigeria. The models for the short-run effects are given in Equations (9) and (10):

$$\Delta AO_t = \delta_0 + \delta_1 \Delta CA_t + \delta_2 \Delta RF_t + \delta_3 \Delta LD_t + \delta_4 \Delta TQ_t + \delta_5 \Delta EX_t + ECT_1 + v_{1t} \tag{9}$$

$$\Delta LA_t = \gamma_0 + \gamma_1 \Delta CA_t + \gamma_2 \Delta RF_t + \gamma_3 \Delta LD_t + \gamma_4 \Delta TQ_t + \gamma_5 \Delta EX_t + ECT_2 + v_{2t} \tag{10}$$

These equations show the short-run behaviour. ECT is the error correction term, which must be significant, and the coefficient must be less than one and negative to show the speed of adjustment to initial equilibrium. All the variables are in 'differenced form', indicated by Δ.

The long-run equations for the two dependent variables are given as (Equations (11) and (12)):

$$AO_t = \varsigma_0 + \varsigma_1 CA_t + \varsigma_2 RF_t + \varsigma_3 LD_t + \varsigma_4 TQ_t + \varsigma_5 EX_t + \omega_{1t} \tag{11}$$

$$LA_t = \kappa_0 + \kappa_1 CA_t + \kappa_2 RF_t + \kappa_3 LD_t + \kappa_4 TQ_t + \kappa_5 EX_t + \omega_{2t} \tag{12}$$

The ECM involves three stages. The first stage is to estimate the long-run relationship using the least square; this was followed by generating the residual from the long-run relationship and testing for stationarity. If the residual is stationary at 5 %, this validates the long-run relationship among the series. Based on the outcome, the third stage estimates the variable's first difference form with the residual lag as the error correction term. Afterwards, the models in this research are subject to diagnostic checks to determine if they are correctly specified.

Given the outcome of the time series properties, since all the series are integrated of order one, the error correction is the most appropriate and suitable for the study. Therefore, it was preferred over the autoregressive distribution (which is more suitable for mixed order of co-integration, that is integrated of order zero and one) and more than the Johansen co-integration equation because the ECM gives a unique equation [24,25]. In contrast, the former gives multiple equations and sometimes makes interpretations not straightforward. In addition, other rationales for this choice of estimation used in this study are as follows: Firstly, it offers a robust analytical approach, particularly in this study, which needs to capture both short-term fluctuations and long-term equilibrium relationships in a system. For example, in Nigeria, there is prolonged high unemployment and poverty rate, and the effect of time perspective implications are important in the agricultural sector. Using ECM enables the study to assess if tractor acquisition can have immediate effects and, likewise, if it can contribute to sustainable changes over time. Secondly, the ECM accounts for dynamic adjustments and measures the speed at which the system returns to equilibrium after the shocks; this is important for policy implications.

One limitation of the ECM is the assumption of linear relationships and stationary data, which might not hold in complex real-world systems. Additionally, the ECM assumes that the variables in the model are co-integrated, which might not always be the case, leading to unreliable results. However, this current study overcame the limitations by conducting a preliminary analysis, in which it was observed that the series used in this study are not stationary and are integrated of order one (as depicted in Table 1). Also, the co-integration test was carried out using the residual lag; evidence from the result shows the presence of co-integration (as depicted in Table 5).

2.3. Data Source and Measurement

Time series data used for this investigation were from the secondary source obtained from the Central Bank of Nigeria (CBN) (www.

cbn.gov.ng), Nigeria Meteorological Agency (NMA) (www.nimet.gov.ng), National Bureau of Statistics, Nigeria (NBS-NG) (www.nigerianstat.gov.ng) and government agricultural agencies (www.fmard.gov.ng) [26–29]. The time series data spanned from 1993 to 2018 for tractor price, annual rainfall, land area cultivated, farmers' population, exchange rate, agricultural output, and credit given to farmers. Data analyses were done using EViews version software to affirm the relationship between the response variable and the predictors.

3. Results and discussion

3.1. Presentation of results output from analysed data

This section presents the unit root test, Johansen co-integration test, agricultural output equation concerning tractor acquisition (Model 1), employment equation concerning tractor acquisition (Model 2), residual unit test, and implications of the findings and evaluation of hypotheses.

3.2. Presentation of unit root test

Table 1 shows the outcome of the stationary test using the Augmented Dickey-Fuller (ADF) approach. The null hypothesis is that the series has a unit root, while the alternative hypothesis is that no unit root exists. The null hypothesis is rejected if the Augmented Dickey-Fuller (ADF) test statistic (absolute values) exceeds the critical values. Otherwise, probability can also be used; significance at any level shows the rejection of the null hypothesis. Using the absolute values, evidence from the result shows that AO, CA, EX, LA, LD, RF and TQ with ADF test statistic values of −0.476108, −1.774045, −1.371228, −0.732250, −2.195118, −2.756186 and 1.087935 respectively is less than the critical value of −2.892536, using 5 % significance level indicates that the series are not stationary. However, considering only the absolute values, RF is stationary at the level of 10 % significance since the absolute value of the ADF test statistics −2.756186 is greater than the critical value of −2.583371.

All the series are integrated of order one I(1) since the series are stationary at the first differencing form. The ADF test statistic values of AO, CA, EX, LA, LD, RF and TQ with −2.948583, −2.940844, −2.948416, −3.045899, −3.483188, −4.919975 and −2.943080 respectively are greater in absolute term than the critical values of −2.892536 at 5 %. Only RF with the value of −4.919975 is significant at 1 %. The study uses a 5 % significance level.

3.3. Presentation of Johansen Co-integration test

The Johansen co-integration test result is presented in Table 2. The test has two statistics: the Unrestricted co-integration rank test (Trace) and the Unrestricted co-integration rank test (Maximum Eigenvalue). The two statistics accept the hypothesis of the presence of co-integrating vectors, showing the presence of two co-integrating vectors. Given the outcome of the result, the short and long-run implications of tractor acquisition on the agricultural sector were analysed by generating two equations to represent the agricultural output and employment, which were used to proxy the performance in the agricultural sector.

3.4. Presentation of output equations concerning tractor acquisition (Model 1)

The agricultural output equation in relation to tractor acquisition is referred to as model 1, while the employment equation in relation to tractor acquisition is referred to as model 2. Table 3 presents the short and long-run impact of tractor acquisition using output in the agricultural sector as the dependent variable. In the long-run equation result, capital proxy by credit to the agricultural sector (CA), exchange rate (EX), land cultivated for agricultural purposes (LD) and tractor acquisition (TQ) are statistically significant since the probability values are less than 0.05. At the same time, rainfall (RF) is not statistically significant. CA, LD and TQ have a positive relationship with output in the long run; this implies holding all the variables constant; a percentage increase in CA, LD and TQ

Table 1
Result of Stationary Test using Augmented Dickey-Fuller (ADF) Approach.

Series	@ Level form	@ First Difference Form	Order of Integration
AO	−0.476108	−2.948583**	I (1)
CA	−1.774045	−2.940844**	I (1)
EX	−1.371228	−2.948416**	I (1)
LA	−0.732250	−3.045899**	I (1)
LD	−2.195118	−3.483188**	I (1)
RF	−2.756186*	−4.919975***	I (1)
TQ	1.087935	−2.943080**	I (1)
Critical Values			
1 %	−3.501445	−3.501445	
5 %	−2.892536	−2.892536	
10 %	−2.583371	−2.583371	

***, ** and * show significance at the level of 1 %, 5 %, and 10 % respectively

Table 2
Johansen Co-integration test results.

Series: AO CA EX LD RF LA TQ				
Unrestricted Co-integration Rank Test (Trace)				
Hypothesised no. of CE(s)	Eigen Value	Trace Statistic	0.05 Critical Value	Prob **
None*	0.788598	276.6346	117.7082	0.0000
At most 1*	0.525874	122.7892	88.80380	0.0000
At most 2	0.220894	48.90739	63.87610	0.4633
At most 3	0.107769	24.19621	42.91525	0.8281
At most 4	0.086164	12.90720	25.87211	0.7454
At most 5	0.039472	3.986896	12.51798	0.7440
Unrestricted Co-integration Rank Test (Maximum Eigenvalue)				
Hypothesised No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical value	Prob. **
None *	0.788598	153.8454	44.49720	0.0000
At most 1*	0.525874	73.88184	38.33101	0.0000
At most 2	0.220894	24.71118	32.11832	0.3035
At most 3	0.107769	11.28901	25.82321	0.9126
At most 4	0.086164	8.920301	19.38704	0.7326
At most 5	0.039472	3.986896	12.51798	0.7440

Trace test indicates 2 co-integrating Eqn.(s) at the 0.05 level. * denotes rejection of the hypothesis at the 0.05 level. ** MacKinnon-Haug-Michelis (1999) p-values. Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level. * denotes rejection of the hypothesis at the 0.05 level. ** Mackinnon-Haug-Michelis (1999) p-values.

Table 3
Short and long-run impact of tractor acquisition on agricultural output.

Long-run Result				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
CA	0.141851***	0.014632	9.694668	0.0000
EX	−0.140647***	0.024594	−5.718665	0.0000
LD	1.282670***	0.315627	−.063881	0.0001
RF	0.038602	0.027532	1.402059	0.1641
TQ	1.468651***	0.056576	25.95887	0.0000
C	−1.317988**	0.677223	−1.946165	0.0545
Short-run Result				
Variable	Coefficient	Std. Error	t-Statistic	**Prob.**
D(CA)	0.110299***	0.013597	8.112010	0.0000
D(EX)	−0.012513	0.018047	−0.693325	0.4898
D(LD)	0.461242	0.309395	1.490789	0.1393
D(RF)	−0.014054	0.017428	−0.806412	0.4220
D(TQ)	0.734551***	0.182095	4.033900	0.0001
U (−1)	−0.067288**	0.027865	−2.414761	0.0176
C	0.000711	0.001228	0.579218	0.5638
R-squared	0.574025	F-stat.; Prob.	21.56093; 0.00000	
Adj. R-squared	0.547402	Durbin-Wat. stat	1.896455	

***, ** and * show significance at the level of 1 %, 5 % and 10 % respectively.
The Durbin-Watson statistics value of 1.896455 is closer to 2, signifying the absence of autocorrelation in the model. The significance of the F-statistics shows how the jointly independent variables explained the dependent variable. The value of the F-statistics is 21.56093, with a probability value of less than 5 %; this indicates that the independent variables jointly explain the dependent variable. R-squared and adjusted R-squared are the coefficient of determination, which measures the goodness of fit. The R-squared and adjusted R-squared values in Table 3 are 0.574025 and 0.547402, respectively, since the values are more than 0.50. It indicates that more than 50 % variation of the independent variables can be explained in the dependent variable. The U (−1) is the error correction term (ECT). Theoretically, the value must be less than one, negative and statistically significant. The value of the ECT is −0.067288 with a probability value of 0.0176; this shows that the model will adjust about 6 % to the initial equilibrium.

will result to about 0.141851 %, 1.282670 % and 1.468651 % increase, respectively, in output. In a similar study by Zhang et al., 2021 [30] on market-oriented agriculture and farm performance: Evidence from rural China, it was affirmed that land endowment, fixed agricultural assets, access to formal credit, and land certification are part of the critical factors affecting farmers' decisions as it relates to agricultural performance.

Arisukwu et al., 2019 [31] stressed the need to increase agricultural production in Nigeria. Takeshima, 2016 [10] emphasised a significant direct correlation between tractor adoption and land development with 0.2 % points in the probit models. Similarly, Asaleye et al., 2020 [23] established that long-term benefits could be maximised by appropriate cotton and groundnut production funding to promote sustainable growth. The study affirmed the importance of finance as a key factor for employment and agricultural output. The exchange rate (EX) is negatively related to agricultural output; an increase in the exchange rate will affect farmers' capacity to acquire tractors and, hence, reduce agricultural output. The result shows that holding other variables constant, a 1 % change in the exchange rate will lead to about 0.140647 % reduction in agricultural output in the long run. The short-run behaviour shows that CA and TQ are statistically significant since the probability values are less than 5 %, while EX, LD and RF were not statistically significant. Likewise, CA and TQ positively impact agricultural output in the short run. A 1 % increase in CA and TQ will promote agricultural output by 0.11 % and 0.73 % respectively. The outcome reveals that access to capital and tractor usage is an impetus for increased agricultural output.

3.5. Presentation of employment Equation in relation to tractor acquisition (Model 2)

Table 4 presents tractor acquisition's short and long-run impact on agricultural employment. Agricultural employment is used as the dependent variable. In the long-run behaviour, capital proxy by credit to the agricultural sector (CA), exchange rate (EX), land cultivated for agricultural purpose (LD), rainfall (RF) and tractor acquisition (TQ) are statistically significant since the probability values are less than 0.05. CA, LD, and RF have a positive long-term relationship with employment; this implies holding all the variables constant; a 1 % increase in CA, LD and RF will result in about 0.034056 %, 0.443985 %, and 0.046359 % increase in employment, respectively.

The short-run behaviour shows that CA, EX, LD, RF and TQ are statistically significant since the probability values are less than 5 %. EX, RF and TQ have a positive relationship with agricultural employment; this shows that holding all other variables constant, a percentage change in EX, RF and TQ will lead to about 0.093964 %, 0.025056 % and 0.612343 % increment in employment in the short-run. CA and LA have a negative relationship with employment; holding all variables constant, a 1 % change in CA and LA will result in about 0.225099 and 0.769325 reductions in employment in the short run.

The Durbin-Watson statistics value is 2.006025, which is close to 2, affirming no autocorrelation in the model. The F-statistics measures the joint significance of independent variables in explaining the dependent variable. The value of the F-statistics is 106.8320, with a probability value of less than 5 %; this indicates that the independent variables jointly explain the dependent variable. R-squared and adjusted R-squared are the coefficient of determination, with values of 0.872686 and 0.863581, respectively, which measures the goodness of fit since the values are more than 0.50. It indicates that more than 50 % variation of the predictors can be explained in the dependent variable.

The U (−1) is the error correction term (ECT). Theoretically, the value must be less than one, negative and statistically significant. The value of the ECT is −0.056612 with a probability value less than 0.05, which shows that the model will adjust about 5 % to the initial equilibrium.

3.6. Residual unit root test

Table 5 shows the stationary result for the two models examined in this investigation. Since the null hypothesis of the unit is rejected at the level of 5 % for both models, this validates the presence of co-integration in the study. Likewise, the models were subjected to various diagnostic checks; the outcome shows that the models are specified correctly.

Table 4
Short and long-run impacts of tractor acquisition on agricultural employment.

Short and long-run Impact of Tractor Acquisition on Employment				
Long-run Result				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
CA	0.034056***	0.007852	4.337163	0.0000
EX	−0.039084***	0.013198	−2.961272	0.0038
LD	0.443985***	0.169380	2.621238	0.0102
RF	0.046359***	0.014775	3.137665	0.0022
TQ	−0.696756***	0.030361	−22.94883	0.0000
C	3.155791***	0.363429	8.683382	0.0000
Short-run Result				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(CA)	−0.225099***	0.011864	−18.97364	0.0000
D(EX)	0.093964***	0.011359	8.271866	0.0000
D(LD)	−0.769325***	0.144312	−5.331002	0.0000
D(RF)	0.025056***	0.006628	3.780056	0.0014
D(TQ)	0.612343***	0.067988	9.006604	0.0000
U (−1)	−0.056612***	0.005084	−11.13533	0.0000
C	0.003086***	0.000247	12.49760	0.0000
R-squared	0.872686	F-stati.; Prob.	106.8320; 0.00000	
Adj. R-squared	0.863581	Durbin-Wat. stat	2.006025	

***, ** and * show significance at the level of 1 %, 5 %, and 10 % respectively.

EX and TQ are negatively correlated to employment as an increased exchange rate will hamper the capacity to acquire tractors for agricultural operations. The result shows that holding other variables constant, a 1 % change in EX and TQ will lead to about 0.039084 and 0.696756 reduction in the output parameter, respectively.

Table 5
Residual stationary test results.

Residual Stationary Test for Model 1			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		−2.656339	0.0083
Test critical values:	1 % level	−2.589795	
	5 % level	−1.944286	
	10 % level	−1.614487	
Residual Stationary Test for Model 2			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		5.480648	0.0000
Test critical values:	1 % level	−2.589795	
	5 % level	−1.944286	
	10 % level	−1.614487	

3.7. Implications of findings and evaluation of hypotheses

The study investigates the effect of tractor acquisition on agricultural performance in terms of output and employment in the short and long run. The hypotheses are stated in null form as follows.

i. There is no significant short or long-run impact of tractor acquisition on agricultural output.
ii. There is no significant short or long-run impact of tractor acquisition on agricultural employment.

The two hypotheses were rejected at the significance level of 5 %; it was depicted from the result in Table 3 that tractor acquisition has a positive effect on agricultural output in the short and long run. This result implies that in the short run, investment in tractor acquisition can increase agricultural output, improving food security and reducing the dependency on imports, moving the economy towards self-sufficiency. Also, this can contribute to lower food prices and enhanced economic stability. In the long run, the positive relationship between tractor acquisition and agricultural output may help sustain agricultural productivity growth. And go beyond promoting aggregate welfare and overall economic development, generating employment opportunities, stimulating rural economies, and encouraging diversification of Nigeria's revenue base.

Likewise, Table 4 shows that tractor acquisition positively affects employment in the short run but negatively in the long run. The implication of tractor acquisition having a positive impact on employment in the short run may be related to the technological advancements and labour dynamics in the Nigerian economy [32,33]. For example, introducing tractors may generate employment opportunities through increased demand for skilled operators and maintenance personnel. However, the negative long-run effect suggests a potential displacement of labour as mechanisation increases; this makes the need to carefully manage the transition to modern agricultural practices, perhaps through targeted policies that promote skill development and diversification of employment opportunities to ensure sustainable and inclusive economic development in Nigeria.

Tractor acquisition and adoption for agriculture are based on economic and environmental factors. The study shows that despite the positive effect of tractor acquisition on agricultural output, the coefficient is still less than 1 %. In this regard, much still needs to be done for the agricultural sector to promote economic transformation, which can increase pro-poor growth. From the investigation, it can be inferred that investment in tractor acquisition and availability to farmers will enhance productivity as a positive relationship was established between agricultural output and employment. Affirmatively, there should be policy interventions towards a clear understanding of the issues connecting to advancing increased engagement of tractors in Nigeria's farming setting. These issues include determining the most appropriate mechanisms to improve farmers' access to tractors, defining the best geographical areas for the government to improve farmers' access to tractor services, and assessing soil characteristics to predict tractor demand [10].

4. Conclusion and policy Recommendations

Access to mechanical farm power such as tractors has always been a challenge to Nigerian farmers, especially at peak periods, because of the limited numbers available to serve or service the vast community of farmers. On the other hand, the increased unemployment rate remained unresolved in Nigeria despite various policies and programmes the Nigerian government has introduced to improve the situation. However, arguments support the agriculture sector's development in the general economic transformation to promote aggregate welfare and development. Given this, the study aimed to examine the short and long-run impacts of tractor acquisition on agricultural output and employment, considering other controlling variables based on their relevance from empirical studies, such as credit to the agricultural sector, exchange rates, land cultivation, and rainfall. The findings from the agricultural output equation show the significance of tractor acquisition alongside other key variables. Credit to the agricultural sector, land cultivated for agricultural purposes, and tractor acquisition are statistically significant contributors to agricultural output. The positive effects of credit and land cultivation persist in the short and long run, indicating their sustained influence on enhancing productivity. The positive relationship observed in the short and long term implies that the advantage from the process can be used to boost aggregate output, Turning attention to the agricultural employment equation, credit to the agricultural sector, exchange rate, land cultivated for agricultural purposes, rainfall and tractor acquisition are statistically significant. Credit to agricultural purposes, land cultivated for agriculture and rainfall have a positive long-term relationship with employment. In contrast, tractor acquisition has a negative impact on agricultural employment in the long run. In the short run, exchange rate, rainfall, and tractor acquisition positively correlate with agricultural employment. While credit for agricultural purposes and land cultivated for agriculture have a negative relationship with employment. Emphasising the role of these factors in sustaining and fostering employment opportunities. However, the impact of tractor acquisition on employment takes an unexpected turn. While the short-term analysis shows a positive relationship, the long-term perspective reveals a negative impact; this suggests that while tractor acquisition may initially create jobs, concurrent strategies might be needed to address potential job displacement in the long run due to increased mechanisation.

Based on the findings, given the positive influence of credit, land cultivation, and rainfall on both output and employment, this shows that strengthening policies that support access to credit, promote sustainable land use practices, and enhance water management is important. Moreover, the impact of tractor acquisition calls for a balanced approach. Policymakers should consider implementing measures that encourage the adoption of tractor technology while simultaneously addressing potential challenges related to job displacement. Also, the study affirmed the importance of finance as a key factor for employment and agricultural output. The outcome reveals that access to capital and tractor usage is an impetus for increased agricultural output. The exchange rate is negatively related to agricultural output; an increase in the exchange rate will affect farmers' capacity to acquire tractors and, hence, reduce agricultural output.

This study examines the macro impact of tractor acquisition on Nigerian agriculture, emphasising the short and long-term effects. While a macro study is important to understand the broader effect, future research may focus on the micro-level to understand individual farm dynamics; this will help by informing targeted interventions for inclusive and sustainable agricultural development. Likewise, bridging macro and micro analyses is crucial for a comprehensive understanding of the growth process and effective policy formulation in Nigeria's evolving agricultural development.

Availability of data and materials

The information and source of data used in this study are detailed in Section 2.3 under the heading of 'Data Source and Measurement'; the links are also provided. In case of further request, the corresponding author can be contacted through the e-mail address: alhassan.elijah@lmu.edu.ng.

CRediT authorship contribution statement

E.A. Alhassan: Writing – review & editing, Writing – original draft, Visualization, Supervision, Resources, Methodology, Investigation, Formal analysis, Conceptualization. **J.A. Asaleye:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **J.K. Biniyat:** Resources, Project administration, Investigation, Conceptualization. **T.R. Alhassan:** Writing – original draft, Resources, Formal analysis. **J.O. Olaoye:** Writing – review & editing, Writing – original draft, Validation, Resources, Methodology, Investigation, Conceptualization.

Declaration of Competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

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