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The Agri-food Sector Output in Ghana and Fuel Prices

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Abstract: *This study seeks to investigate the impact of crude oil prices on agriculture output in Ghana through addressing three research objectives. The Cobb-Douglas production function was used to explore the practical impact of global crude oil prices on agricultural output in Ghana, Annual time-series data from 1980 to 2020, sourced from the WDI and the US Energy Information Administration. Variables such as agriculture value added per GDP, international Brent crude oil prices, agricultural employment as a percentage of total employment, agriculture machinery and tractors, and agricultural land as a percentage of total land were considered. Additionally, the study delved into the consumption patterns of crude oil in both the agricultural sector and the overall Ghanaian economy, covering the period from 2000 to 2021. The Autoregressive Distributed Lag cointegration technique was employed to assess the short and long-term relationships among the variables. Before this analysis, a unit root test was conducted to determine the stationarity of the variables. The EViews Statistical/Econometric package facilitated the analysis, with graphical representations illustrating the crude oil consumption patterns in both the agricultural sector and the entire economy. The findings of the Autoregressive Distributed Lag cointegration estimates revealed a negative correlation between international crude oil prices and agriculture value added per GDP. The model indicated that all variables were cointegrated in both the short and long run. The study recommends implementation of crude oil price hike-resistant and mitigation policies to minimize the its negative effect on Agricultural output in Ghana.*

Keywords— *Secondary Data, Time series, EViews, GDP, Fuel Price, Autoregressive Distributed Lag, Ghana*

1. Introduction

Ghana is a West African nation with a predominantly agrarian economy, where agriculture plays a crucial role in the livelihoods of a significant portion of the population. The agricultural sector in Ghana encompasses various subsectors, including crop production, livestock farming, and fisheries, contributing significantly to the country's Gross Domestic Product (GDP) and employment. The sector stimulates the overall economy by strengthening key economic fundamentals like exchange rate, employment and price levels through the improvement of balance of payment (trade balance surplus), absorption of many citizens directly and indirectly in the sector and decreased import of substitutable product respectively. The IMF (2012) has intimated that, agriculture on average contributes about 15 percent of Africa’s gross domestic product, and more than 50 percent of the total labor force are employed in this sector. Thereby, remaining as one of the most important economic sectors of not only the continent, but also the United Nation, as it seeks to tackle global issues like hunger and poverty eradication across continents.

In Ghana, agriculture is considered the backbone of the economy (Aryeetey, 2000), with a sector to GDP contribution of about half in the 1950s, which witnessed consistent decline to about 17.31 percent in 2019. And about 28.46 percent of Ghanaians are directly employed in this sector as at 2020. According to Oteng-Abayie etal (2018), agriculture value added per GDP which was 60 percent in the late 1970s all the way to early 1980s experienced a decline to about 50 percent in the 1950’s, fell to 40 percent in the 1990s, and remain afloat above 35 percent until 2008 when it decreased further to 32 percent. The sector as at 2019 comes third only to the industry and services sector which contributed 31.99 percent and 44.14 percent to GDP respectively in Ghana.

The sustainability of this delicate sector however depends on a lot of factors which include human capital, Government policies and availability of natural resources (land, water and energy) since a rise in food production leads to an upshot in the use of vital resources like energy, water and so on. This is so because, almost all the value chain in food production requires the use of energy and water and this relationship between food, energy and water has been clearly identified and captured as priority areas under the sustainable development goals (SDGs), with interactions evident between three of the SDGs targets which are the SDG 2-Food Security, SDG 6-Water and Sanitation and SDG 7-Energy access. Meaning, food, energy and water interaction is a vital component of the 2030 agenda for attaining sustainable development goals (SDGs) (OFID, 2017). According to the IEA (2012), the global demand for energy is expected to grow by 30% in 2040 relative to the 2014-year figures albeit the declining energy intensity trend witnessed by developed countries. Most of this rise will emanate from developing and emerging economies, and especially in China and India. Ghana is not excluded from this rising demand for energy as its fishing industry, timber, cocoa farms and large-scale farming heavily depend on energy. This implies that the performance of the agricultural sector is susceptible to various external and internal factors, including world fuel prices. This research aims to investigate the effect of world fuel prices on agricultural output in Ghana. Some of the main sources of energy in Ghana are biofuel and waste, accounting for approximately 69.5 percent which is largely for cooking purposes, 24.1 percent from crude oil and 6.4 percent from hydro (IEA, 2012). According to Armah (2003), Ghana's productive economic sectors like agriculture, manufacturing and transport rely heavily on crude oil and that 96.7 percent, 92 percent and 52 percent of the energy consumed respectively by agriculture, transport and the formal manufacturing sector is crude oil, and so these sectors will indubitably face shock from changes in international crude oil price. This is only rational since the country has no influence on the price of crude oil imported, and so, small hike in prices trickles down to the very micro level of the economy, affecting the price of almost everything in the country. There are a lot of works carried out on the relationship between crude oil prices and economic growth in Ghana and abroad. Fosu & Aryeetey (2008), Aryeetey & Harrigan (2000) works for instance shows that crude oil price shock had a negative effect on the economy. However, the effect of crude oil prices on the agricultural sector has not received much attention especially in Ghana. This therefore necessitate the need to understand the effect of crude oil prices on agricultural sector as this will add to literature. A recent paper the author cited which looked at this similar relationship was conducted by the Australian Farm Institute in 2018 titled "the impact of energy cost on the Australian Agricultural Sector" and they found out that fuel (diesel, petrol and oil) forms the biggest energy cost in Australian Agricultural sector which stood at 2.5 billion annually followed by electricity. This research therefore intends to provide more insight and understanding about the relationship between crude oil prices and agriculture output in Ghana. This relationship between world fuel prices and agricultural output in Ghana is a critical aspect of the country's agricultural development. Understanding how changes in fuel prices impact this sector is essential for informed policy formulation and decision-making. This research will contribute to the existing body of knowledge and provide valuable insights that can inform government policies and interventions to mitigate the negative effects of unstable fuel prices on Ghana's agriculture, ensuring food security and economic sustainability.

1.2 Problem Statement

Ghana is still exposed to shock from international prices of crude oil albeit currently a producer of oil in commercial quantities. This is because the country still imports significant crude oil and other refined products, therefore an upsurge in international crude oil prices causes a substantial upshot in the price of almost all commodities in the market and this shock is felt much more now as a result of the deregulation carried out in the sector by Government in 2014 which ensures that consumers are burdened by any surge in world market prices. According to the Institute of Fiscal Studies (IFS, 2015), Ghana imported 3.4 billion United States dollar worth of crude oil and refined products in 2013, and because of this increasing dependency on this commodity (World Bank, 2005), Ghana is vulnerable to shocks from international crude oil prices.

A fall in prices of international oil also affects the Government budget since the country depends on flows from the export of this commodity to finance most of its expenditures. According to the Institute of Fiscal Studies (IFS, 2015), a fall in international crude oil price affects Government fiscal space in Ghana. This dependence on oil by the Ghanaian economy has led to a lot of research carried out to examine the relationship between the price of this commodity and economic growth. Fosu & Aryeetey, 2008, Aryeetey & Harrigan, 2000 works for instance shows that crude oil price shock had a negative effect on the economy.

The effect of international crude prices on specific productive sector such as agriculture has equally garnered attention from researchers. Previous research has highlighted the relevance of this topic. For example, a study by Wiggins and Keats (2003) investigated the influence of fuel price changes on agricultural production in Sub-Saharan Africa, concluding that higher fuel prices tend to reduce agricultural productivity by increasing production costs. Additionally, research conducted by Onumah, Breisinger, and Thurlow (2012) in Ghana used micro-level data to indicate that fuel price hikes can lead to a decline in agricultural output by making farming operations less cost-effective.

This article adopts macro-data and focuses specifically on Ghana to examine local context and nuances of the relationship between world fuel prices and agricultural output. It aims to provide empirical evidence to better understand how fuel price fluctuations affect different agricultural sector in Ghana and the potential policy implications for enhancing agricultural resilience in the face of global energy price changes. It has been established by (IEA, 2012) that Ghana's energy sources are biofuel and waste accounting for approximately 69.5 percent which is largely for cooking purposes, 24.1 percent from crude oil and 6.4 percent from hydro, and of the crude oil consumption. Ghana's productive economic sectors like agriculture, manufacturing and transport are the main consumers, with 96.7 percent of agriculture's energy consumption being crude oil (Armah, 2003) and so these sectors will undoubtedly face shock from the crude oil price changes. This, therefore necessitate the need to investigate the relationship between international crude oil prices and agricultural output in Ghana.

1.3 Objectives of the study

1. To analyse the pattern of crude oil prices and consumption in Ghana.
2. To examine short run effect of crude oil price on agriculture output in Ghana

3. To estimate the long run effect of crude oil price on agriculture output in Ghana

1.4 Research Question

1. What is the pattern of crude oil prices and consumption in Ghana?
2. What is the short run effect of international crude oil price on agriculture output in Ghana?
3. What is the long run effect of international crude oil price on agriculture output in Ghana?

1.5 Impact of the Study

This study which seeks to investigate the effect of international crude oil prices on agricultural output in Ghana is very relevant for economic planning, ensuring food security, and formulating policies that foster the resilience and sustainability of the agricultural sector in the face of global economic fluctuations. This is because Changes in international crude oil prices can have cascading effects on the overall economy, it can directly affect the cost of farming inputs because when oil prices rise, it can lead to an increase in production costs for farmers, potentially reducing their profit margins and unstable crude oil prices can engender disruptions in agricultural output cand hence have a direct consequence on food availability and affordability. Therefore, understanding how these changes impact the agricultural sector is crucial for economic planning and policymaking, as well as developing concrete strategies to mitigate the impact of oil price volatility on input costs in agriculture and understanding the potential challenges to food security so as to implement measures to address them.

2.0 LITERATURE REVIEW

2.1 Review on the Measure of Agricultural Production

The typical production theory expresses output as a function of input, implying that there cannot output without input. This is known as input-output relationship, and the earlier input variables used to explain variations in output were capital and labor. For instance, in 1927, the Cobb-Douglas production function was estimated for the purpose of understanding input-output relationship by employing an econometric model and aggregate time series data on physical output, capital and labor from a manufacturing sector in the United States of America (Biddle, 2010). However, different variables like land, fertilizer use, irrigation, seed, exchange rate and crude oil prices have been incorporated in this simple model to account for their effect on production. See Turkful and Unakitan (2011), (Hamilton, 1983), Hooker (1996). According to Dharmasiri etal, 2011, three different economic models have been extensively employed to measure aggregate agricultural output and these are the econometric estimation, nonparametric and growth accounting models. This paper, using the Cobb-Douglas production function will adopt the econometric estimation technique due to its ability to estimate marginal effects of each explanatory variable on output.

2.2 Oil Price and Input Costs in Agriculture

The agriculture industry is highly dependent on various inputs such as fuel, fertilizers, pesticides, and machinery. These inputs are essential for crop production and can significantly impact the overall cost of farming operations. One of the major factors influencing input costs in agriculture is the price of oil. According to Vedenov & Power (2005), most direct and noticeable impacts of oil prices on agriculture is the cost of fuel. Agricultural machinery, including tractors, combines, and irrigation systems, typically rely on diesel or gasoline. When oil prices rise, fuel costs increase, causing farmers to spend more on operating their equipment. This, in turn, can raise the overall cost of production. A study conducted by Runge etal (1986) to investigate the impact of rising prices of fuel on the future of food concluded that crude oil is a crucial component in the production of synthetic fertilizers. As oil prices surge, so do the costs of manufacturing and transporting fertilizers. This, in turn, can result in higher prices for fertilizers, making it more expensive for farmers to provide essential nutrients to their crops. Fuel prices also influence agriculture output through agricultural input such as production of pesticides and herbicides, transportation cost, irrigation and energy Costs. For instance, A study by Almuhtaseb etal (2008) to understand the relationship between crude oil and agricultural commodity prices intimated that the production of pesticides and herbicides depends heavily on oil-derived chemicals. Therefore, when oil prices increase, the cost of manufacturing these agricultural chemicals rises, hence affecting the overall input costs for crop protection.

Transportation and irrigation system are a critical component of the agricultural supply chain and production respectively. Higher oil prices lead to increased transportation costs for moving crops and livestock from the farm to processing facilities or markets. These costs ultimately get passed on to consumers and can impact the profitability of agricultural operations (Alves, 2013). Transportation costs play a pivotal role in agriculture, affecting the movement of goods from farms to markets. Crude oil prices directly impact fuel costs, which, in turn, influence transportation costs. A study by Balcombe et al. (2009) found that an increase in oil prices significantly raises transportation costs for agricultural products, reducing farmers' income and limiting market access. Such constraints can hinder the distribution of agricultural products and ultimately affect output, particularly for remote or export-oriented regions.

Irrigation is vital for maintaining crop productivity, and many irrigation systems rely on electricity or fuel to operate. When oil prices surge, the energy costs associated with irrigation can rise, affecting the overall expenses for water management in agriculture (Shahnazari etal 2010).

The price of oil has a substantial impact on input costs in agriculture, influencing everything from fuel and fertilizer expenses to transportation and energy costs. As oil prices fluctuate, farmers must adapt to these changes and implement strategies to mitigate the impact on their bottom line. Policymakers, agricultural economists, and industry

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stakeholders should closely monitor oil price trends and their effects on agriculture to develop solutions that can help the farming community navigate these challenges (Shahnazari etal 2010). Although the relationship between oil prices and input costs in agriculture is complex, and various factors can mediate these effects. Nevertheless, understanding this connection is crucial for farmers, researchers, and policymakers as they work to ensure the sustainability and profitability of agriculture in an ever-changing economic landscape.

2.3 Oil Price effects on Crop Choices and Land Use

The fluctuation of crude oil prices can also alter the choice of crops and land use patterns. High oil prices may encourage farmers to shift toward biofuel crops such as corn and soybeans, as they become more economically viable for both food and energy production. Research by Tokgoz et al. (2006) underscores the importance of this factor, suggesting that an increase in oil prices can lead to an expansion of biofuel crop cultivation and a decrease in food crop production. Such shifts can have significant implications for food availability and prices. High oil prices increase the cost of fuel, which directly affects the expenses associated with mechanized agriculture, such as tractors, irrigation, and transportation of crops. To mitigate for this, farmers may opt for crops that require less mechanization or fuel-intensive practices when oil prices are high, shifting towards more sustainable and energy-efficient agricultural practices. Also, high oil prices can prompt farmers to rethink the practice of monoculture (growing a single crop) due to its dependency on mechanization and chemicals and diversifying crop choices can lead to more resilient and sustainable land use as it mitigates the risk of pests, diseases, and soil degradation.

2.4 Macro-Level Economic Implications of Oil Prices

Oil prices have been a subject of intense interest for policymakers, economists, and researchers worldwide due to their significant impact on the global economy. The fluctuations in oil prices, driven by various factors, have far-reaching consequences on macroeconomic variables such as economic growth, inflation and balance of payments, making it a crucial area of study.

The relationship between oil prices and economic growth is a well-researched topic. Several studies have found that abrupt increases in oil prices can lead to reduced economic growth (Hamilton, 1983). These findings are grounded in the fact that higher oil prices increase production costs, reduce consumer purchasing power, and can lead to inflationary pressures, all of which can negatively affect GDP growth. A lot of studies have been carried out to investigate the correlation between crude oil price and economic growth both in Ghana and abroad.

For instance, in the United States, it was found that crude oil price is negatively correlated with the growth of the economy (Hamilton,1983) This outcome was further entrenched by Hooker (1996), who predicted that a 10 percent rise in oil prices is likely to dwindle U.S economic growth by 0.6 percent in approximate terms. Similar negative relative correlation between oil prices and the growth of an economy was found by Lee et al (1995) and Hamilton (1996) in New Zealand.

Gronwald (2008) investigated effects of substantial oil price shocks on the US economy from 1959 to 2004 using the Vector Autoregressive model (VAR). The study identified that the revised oil price specification successfully distinguishes between "significant" and "typical" oil price increases. It was observed that the influence of oil price shocks on real GDP growth can be largely attributed to three major oil price increases: the ones occurring in 1973-1979 and 1991. Meanwhile, variables such as consumer and import prices were also impacted by more usual oil price increases. The study's conclusion emphasized that the global economy has consistently grappled with significant oil price shocks in recent decades, with notable examples including the oil crises of the 1970s and 1980s, as well as the oil shock triggered by the Gulf War in the early 1990s.

2.5 History Perspectives of Crude Oil Prices

In the mid-20th century, oil prices were relatively stable, but significant shifts occurred in the 1970s. The oil crisis of 1973, triggered by the Arab oil embargo, led to a quadrupling of oil prices. This event highlighted the vulnerability of the global economy to disruptions in the oil supply (IEA, 2019).

Fast forward to the 1980s, and oil prices experienced a sharp decline due to oversupply. The increased production by OPEC members, particularly Saudi Arabia, flooded the market and led to a prolonged period of low prices.

The late 1990s and early 2000s saw a more stabilized oil market, with prices ranging between $20 and $40 per barrel. However, the 21st century brought new challenges. The Iraq War in 2003 and the geopolitical tensions in the Middle East contributed to volatility in oil prices, pushing them to record highs (IEA, 2019).

The global financial crisis in 2008 had a significant impact on oil prices, causing a sharp drop. As economies recovered, prices rebounded, reaching over $100 per barrel in the early 2010s.

In recent years, technological advancements in oil extraction, particularly the boom in shale oil production in the United States, have added a new dimension to the oil market dynamics. This surge in supply has contributed to lower prices, fundamentally altering the traditional OPEC-dominated landscape. It's important to note that oil prices are influenced not only by geopolitical events and economic factors but also by shifts towards renewable energy sources and global efforts to combat climate change. These factors introduce an element of uncertainty into the future trajectory of crude oil prices (IEA, 2019).

2.6 Crude Oil Consumption in Ghana

In Ghana, the consumption of crude oil has undergone significant changes over the years. Historically, Ghana has been a net importer of crude oil to meet its growing energy demands. The discovery of oil in commercial quantities in the offshore Jubilee field in 2007 marked a turning point in the

country's energy landscape (NES, 2021). After the start of oil production in 2010, Ghana experienced a surge in crude oil consumption to fuel power plants and meet the demands of its rapidly growing economy. The government has been working on leveraging the newfound resource to enhance energy security and drive economic development (NES, 2021).
Ghana's energy mix has traditionally been dominated by hydroelectric power, but the discovery of oil provided an alternative source to diversify the energy sector. The government implemented policies to incorporate oil into the energy mix while addressing challenges such as infrastructure development, environmental concerns, and revenue management (NES,2021).

3.Methodology

This section presents the methodology adopted in the study to achieve the objectives of the study.

3.1 Data Source and Description

This work employed secondary data. Data on international crude oil prices, agriculture employment per total employment, and agricultural machinery and tractors, agricultural land per total land and agricultural value added per GDP spanning from 1980-2020 were derived from the World development indicators (WDI) and US Energy Information Administration (EIA).

3.1.1 Dependent Variable

The Agricultural value added per GDP which includes the total crops produced, animals, fisheries and all agricultural products is a measure that assesses the contribution of the agricultural sector to the overall Gross Domestic Product (GDP) of a country. It is often expressed as a percentage or ratio. The formula for calculating agricultural value added per GDP is:
Agricultural Value Added per GDP=
(Agricultural Value Added/GDP) ×100. The measure is the dependent variable in the study. In the model, Y represents the variable.

3.1.2 Explanatory Variables

The explanatory variables employed in the study include international crude oil prices (OilP), agriculture employment per total employment proxied as agricultural labor (L), agricultural machinery and tractors proxied as capital (K) and agricultural land per total land (Land). Brent crude oil is produced in Europe and is a global benchmark that trades on London's exchange. The brent crude oil prices were adopted in this study because Ghana largely buys brent crude oil.

3.2 Model Specification

The typical production theory expresses output as function of capital and labor just like the Cobb-Douglas Production Function which this paper intends to adopt to estimate the effect of crude oil price on agriculture value added per GDP. The traditional Cobb-Douglas production function is a mathematical formula used to represent the relationship between inputs and outputs in a production process. It's named after economists Paul Douglas and Charles Cobb, who introduced it in the 1920s. The general form of the Cobb-Douglas production function is:

$$Y=A\cdot L^{\alpha}\cdot K^{\beta}$$

Where,

- Y is the output of the production process.
- L is the quantity of labor input.
- K is the quantity of capital input.
- A is the total factor productivity or technological factor.
- α and β are the output elasticities of labor and capital, respectively.

The exponents α and β represent the share of each input in the production process. The sum of α and β gives the overall returns to scale. If $\alpha+\beta=1$, it implies constant returns to scale; if $\alpha+\beta>1$, it implies increasing returns to scale; and if $\alpha+\beta<1$, it implies decreasing returns to scale.
The Cobb-Douglas production function is widely used in economics for its simplicity and applicability in modeling production processes and analyzing the impact of changes in input levels on output.

To achieve this paper's objective by running an econometric analysis, we take the natural logarithm of both sides to get the linearized form:

$$\ln(Y)=\ln(A)+\alpha\cdot\ln(K)+\beta\cdot\ln(L)+\varepsilon t$$

This linearized form allows for easier estimation using linear regression techniques. The coefficients obtained from the linear regression will then be used to estimate the elasticities of output with respect to capital and labor.
To achieve the objective of estimating the effect of international crude oil prices on agri-food output, this thesis adopts the neoclassical theory of growth employed in examining crude oil price and economic growth by many researchers like Hamilton (1983) and Hooker (1996). The thesis incorporated oil price as well as agricultural land which are very important in agricultural production to estimate the effect of world crude oil prices on agricultural output. Therefore, the linearized expanded Cobb-Douglas function in this study becomes:

$$\ln(Y)=\ln(A)+\alpha\cdot\ln(K)+\beta\cdot\ln(L)+\beta\cdot\ln(OilP)+\beta\cdot\ln(Land)+\varepsilon t \quad (2)$$

Where Y represents Agriculture value added per GDP, K stands Capital which is proxied by tractors and machineries, L for Agricultural labor employment per total employment, Land for Agricultural land and OilP for world crude oil prices, and Ɛ is the error term.

3.3 Research Design

Economic quantitative analysis was employed to investigate the effect international crude oil prices on agricultural output in Ghana. Correlational research design was employed. It is a type of research method that examines the statistical relationship between two or more variables without necessarily implying a causal relationship. In other words, it investigates whether, and to what extent changes in one variable are associated with changes in another variable.

Correlation does not imply causation; it simply suggests that there is a relationship between the variables: The crude oil price and agricultural output in the short and long run relationship. and consumption pattern were conducted using graphs and estimating the effect of crude oil prices changes on agricultural output, Autoregressive Distributed Lag (ARDL) cointegration test was employed.

3.4 Unit Root Analysis

Unit root analysis is a statistical method used in time series analysis to determine if a variable is non-stationary (Hamilton, 1994). In simpler terms, it helps us understand whether a series has a tendency to return to a certain level over time or if it exhibits a long-term trend.

When a time series has a unit root, it implies that the series is non-stationary, meaning its statistical properties like mean and variance are not constant over time. Unit root tests, such as the Augmented Dickey-Fuller (ADF) test or the Phillips-Perron test, are commonly used to assess whether a unit root is present in a time series.

If the unit root is not present, it suggests that the series is stationary, and its statistical properties remain relatively constant over time. Stationary time series are often easier to analyze and model (Dickey & Fuller, 1979).

In finance, for example, unit root analysis is frequently used to examine the behavior of financial variables over time and to assess the efficiency of financial markets. It's a powerful tool in understanding the underlying dynamics of time series data.

The most common test for unit root analysis is the Augmented Dickey-Fuller (ADF) test. The null hypothesis of the ADF test is that a unit root is present in the time series, indicating non-stationarity. If the test statistic is less than the critical value, the null hypothesis is rejected, suggesting stationarity. In this study, the Augmented Dickey-Fuller (ADF) test was used to assessed whether the variables have unit root or not, that is whether the variables were stationary or non-stationary (Dickey & Fuller, 1979).

3.5 Cointegration

Cointegration analysis is a statistical technique used to investigate the short and long-term equilibrium relationship between two or more time series (Dickey & Fuller, 1979). It's often applied in the context of financial markets, economics, and other fields. If the individual time series are non-stationary but Cointegrated variables exhibit a sustained connection, moving in tandem without deviation. Consequently, any alteration in one variable promptly influences all others and continues to do so over time.

The theory posits that variables integrated at order one (1) have the potential for cointegration. In instances where the individual variables share the same order of integration and, at the very least, one stationary linear combination, the considered variables are deemed cointegrated. Conversely, variables lacking cointegration indicate a short-term relationship (Dickey & Fuller, 1979).

The cointegrating equation can be represented as: $Yt=\beta 0+\beta 1 Xt+\varepsilon t$ where Yt and Xt are the cointegrated series, $0\beta 0$ and $1\beta 1$ are coefficients, and εt is the error term. In this study, the Autoregressive Distributed Lag (ARDL) was adopted to carried out the cointegration regression analysis using EVIEWS.

3.6 ARDL Cointegration Residual Test

The ARDL (Autoregressive Distributed Lag) residual test is a diagnostic test in econometrics to that is used to assess the adequacy of an ARDL model by examining the residuals (the differences between the observed and predicted values) of the model (Dickey & Fuller, 1979). This test helps verify the assumptions and validity of the estimated ARDL model. The assumptions to be verify include serial correlation or autocorrelation, heteroskedasticity and normality of the error terms. Autocorrelation test is conducted to determine whether the values of a time series variable are correlated with their past values and the test for normality examines whether the residuals follow a normal distribution. Normality is important for the validity of statistical inferences, such as hypothesis testing and confidence intervals.

Heteroskedasticity test assesses whether the variance of the residuals is constant or non-constant across all levels of the independent variables. Heteroskedasticity just like autocorrelation and normality test are crucial for the reliability of the model's estimates.

4RESULTS AND DISCUSSION

4.1: Unit Root Test Results

Table 4.1 presents the result of the root test analysis conducted on all the variables included in the Autoregressive Distributed Lag Cointegration model. The test is carried out to determine the stationarity or otherwise of the variables. The results presented in table 4 indicates that, all the variables: Agriculture value added per GDP (In_Y), Crude oil price (In_OilP), Agriculture employment per total employment (In_L), Agriculture Machinery and Tractors (In_K) and Agricultural land per total land (In_Land) were not stationary at level, hence we fail to reject the null hypothesis. On the contrary, when subjected to the Augmented Dickey-Fuller (ADF) test at the first difference, all variables exhibit stationarity at a 1% significance level. That is the variables were integrated at order one I(1). Consequently, we reject the null hypothesis of a unit root at the first difference for these variables. Implying that the time series variables were stationary, meaning their means and variances, remain constant over time. Stationary variables adjust to their trend level when impacted by a shock. The shock induces only a temporary change in the stationary variable, with the variable eventually returning to its original trend level in the long run. Therefore, making it appropriate to apply cointegration regression modelling technique such as Autoregressive Distributed Lag which this thesis adopted.

Table 4.1: Unit root test (Test of Stationarity)

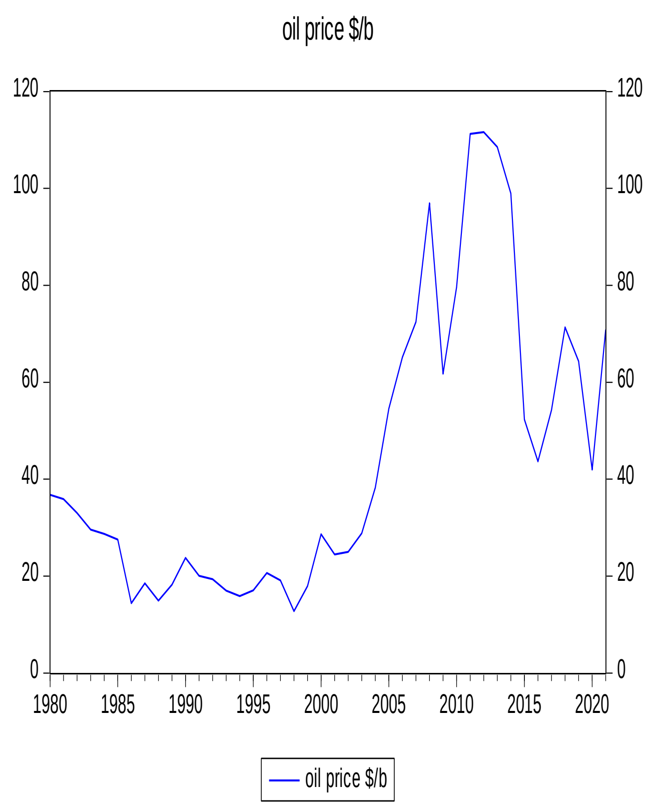
	ADF Test at Levels		ADF Test at 1st Difference	
Variables	Constant	P-value	Constant	P-value
In _Y	0.069	0.820	-0.039	0.000***
In _OilP	0.286	0.693	0.023	0.000***
In _L	0.000	0.939	-0.016	0.000***
In _K	0.188	0.291	-0.002	0.000***
In _Land	0.871	0.155	0.002	0.000***

*The p-values for both levels and 1st difference with *, ** and *** implies significant at 10, 5 and 1 percent respectively.*

4.2 Graphical Presentation of International Crude Oil Prices

Graph 4.1 below presents the annual international brent crude oil prices between the period of 1980 to 2020. The crude oil prices were in dollar per barrel. It can be observed from the graph that, oil prices took a sharp rise from 38.47 dollars per barrel in 2004 to 54.57 dollars per barrel in 2005, the highest ever as at then. It continuous to rise annually reaching astronomically 96.94 dollars per barrel in 2008 during the US financial crises. Afterwards, it fell back, albeit for a year, and then took a skyrocketing upsurge consistently from 2010 to peak at 111.63 dollars per barrel in 2012, the highest ever. Between 1980 to 2020, the lowest price was witnessed in 1998, which was 12.76 dollars per barrel.

Graph 4.1: Annual World Crude Oil Price 1980-2020



Graphical (BAR) Presentation of Total Crude Oil Consumption in Ghana's Economy

From the Bar chart presented in graph 4.3 which presents the total crude oil consumed in the economy of Ghana between 2000 to 2021 in thousand metric tons (kt), it is observed that the years that witnessed the lowest and highest crude oil consumption in Ghana were 2000 and 2021 respectively. In 2000, the total crude oil consumption was 1,442 thousand tons (kt) while 4,638 thousand tons (kt) was consumed in 2021. Largely, the amount of crude oil consumed fairly increases annually in Ghana.

Graph 4.2: Total Crude Oil Consumption in Ghana 2000-2021

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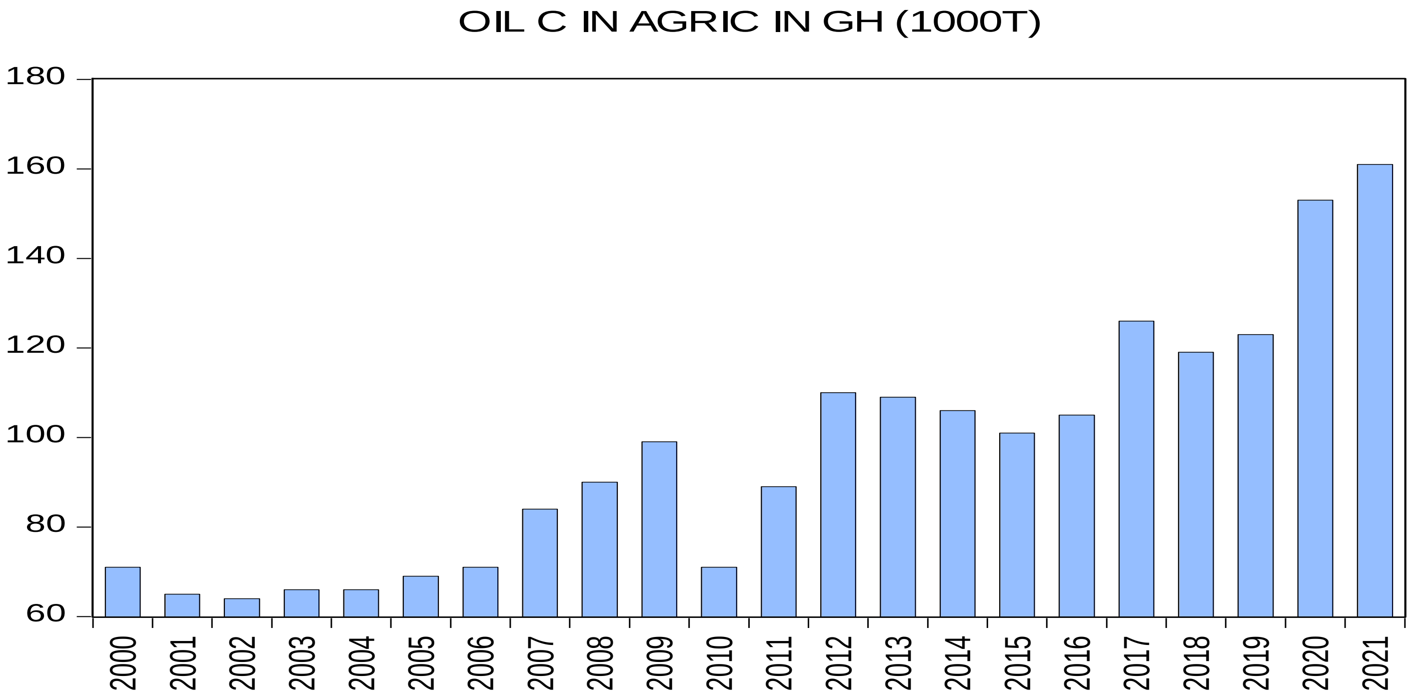

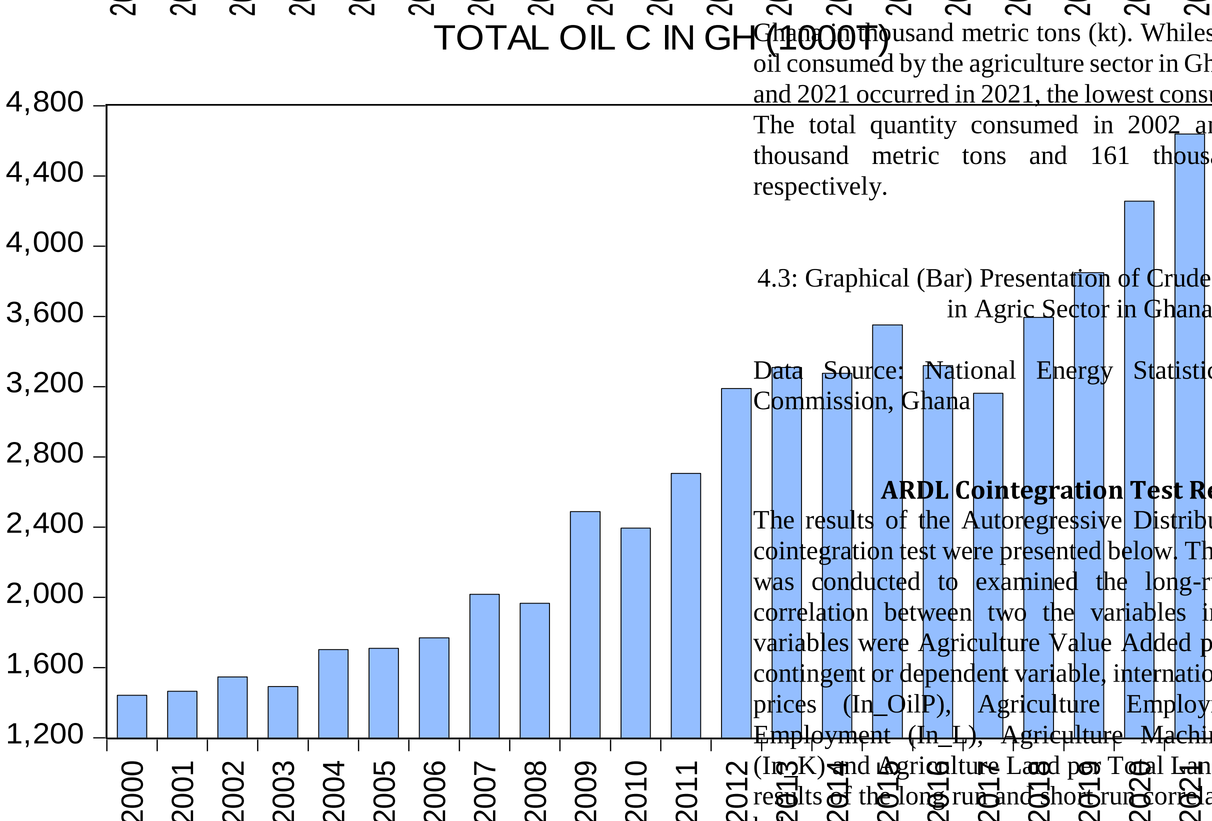

Data Source: National Energy Statistic 2021, Energy Commission, Ghana.

4.4 Graphical (BAR) Presentation of Total Crude Oil Consumption in Ghana's Agric Sector

The graph 4.3 below presents the total annual crude oil consumption in the agriculture sector of the economy in Ghana in thousand metric tons (kt). Whiles the highest crude oil consumed by the agriculture sector in Ghana between 2000 and 2021 occurred in 2021, the lowest consumed was in 2002. The total quantity consumed in 2002 and 2021 were 64 thousand metric tons and 161 thousand metric tons respectively.

4.3: Graphical (Bar) Presentation of Crude Oil Consumption in Agric Sector in Ghana

Data Source: National Energy Statistics 2021, Energy Commission, Ghana

ARDL Cointegration Test Results

The results of the Autoregressive Distributed Lag (ARDL) cointegration test were presented below. The econometric test was conducted to examined the long-run and short-run correlation between two the variables in the study. The variables were Agriculture Value Added per GDP (In_Y) as contingent or dependent variable, international brent crude oil prices (In_OilP), Agriculture Employment per Total Employment (In_L), Agriculture Machinery and Tractor (In_K) and Agriculture Land per Total Land (In_Land). The results of the long-run and short-run correlation are presented below:

4.5.1 Long-run ARDL Regression Coefficients Estimates

The table 4.4 below captures the long-run relationship between the dependent variable: agriculture value added per GDP and the explanatory variables in the study. The sign and magnitude of the coefficients or marginal effects tell us the direction and intensity of the relationship, and probability vale: p-value inform us of whether the correlation is significant, and if it is significant, by what level.

From the results in table 4.4, the coefficient of international crude oil price (In_OilP) is negative and p-value is 0.094, indicating that negative relationship between agriculture output and crude oil prices is significant at 10%. The interpretation is that, a dollar per barrel rise in international brent crude oil price leads to fall in agriculture output by 0.18% all else constant. This outcome corroborates the long-held theoretical and empirical understanding in the relationship between oil prices and agriculture output. Oil is a significant input in agriculture, used for fueling machinery, transportation, and producing fertilizers and pesticides. An increase in oil prices therefore can lead to higher production costs for farmers, affecting their output and profitability. Rising oil prices can also influence the prices of other inputs, such as transportation costs for delivering agricultural products to markets.

Secondly, the long-run relationship between agricultural labor (In_K) and agricultural value added per GDP is positive and significant at 1%. The sign and magnitude of the agricultural labor coefficient is 0.952. This implies that, increasing agricultural labor tends to increase agricultural output productivity, and specifically suggest, a 1% rise in agricultural labor per total labor increases output by 0.95 percent all else constant. Positive marginal returns of labor in agriculture in Ghana makes sense since agriculture in Ghana is laborintensive, therefore an increase in agricultural labor may lead to higher output, as more hands are available for tasks like planting, harvesting, and tending to crops.

The next is the coefficient of agricultural machinery and tractors (In_K) which is positive 3.153 with a p-value of 0.011. This implies a direct and significant relationship between agricultural machineries and tractors and agricultural output. And the interpretation is that, a 1 increase in the number of agricultural machinery and tractors would leads to 3.153% increase in the agricultural output. This is so because agricultural machinery, such as tractors, combines, and harvesters can significantly enhance the efficiency of various farming activities and inputs including labor, planting, harvesting, and irrigation. It can also save time and improve agriculture precision.

Finally, the p-value of agriculture land is 0.149 which implies that the agriculture land was not significant in influencing agriculture output in the model. Indeed, the relationship between land and agricultural output is multifaceted, and depends not only on quantity of the land but on other factors such as the quality of the land, technology adoption, and sustainability practices. Efficient land use, coupled with sound agricultural management practices, is essential for maximizing agricultural output and ensuring long-term food security.

Table 4.4 Long-run ARDL Regression Estimates
Dependent Variable: Y=AV_GDP (Agriculture Value Added per GDP

Variable	Coefficient	Standard Error	P-Value
In _OilP	-0.176*	0.102	0.094
In _L	0.952*	0.333	0.007
In _K	3.153**	1.181	0.011
In _Land	-1.930	1.275	0.139
Constant	-15.730	10.647	0.149

*The p-values for coefficients with *, ** and *** implies significant at 10, 5 and 1 percent respectively*

4.5.2 Short-run ARDL Regression Coefficients Estimates

Here, just like in the long-run regression estimates, 4 of the variables including the lag value of the dependent variables were significant whiles one of the variables which agricultural land is insignificant in explaining agriculture output. The significant positive explanatory variables were international crude oil prices, agricultural labor, agricultural machinery and tractors and the lag value of the agriculture value added per GDP. To avoid repetition, the detailed exposition is not done here.

Table 4.5 Short-run ARDL Regression Estimates
Dependent Variable: Y=AV_GDP (Agriculture Value Added per GDP

Variable	Coefficient	Standard Error	P-Value
In $\_Y_{(-1)}$	0.593***	0.124	0.000
In _OilP	-0.072**	0.033	0.038
In _L	0.388*	0.228	0.098
In _K	1.284**	0.535	0.022
In (Land)	-0.786	0.499	0.124
CointEq (-1)	-0.407	0.124	0.002

These findings affirm the long-term estimates and the speed of adjustment: CointEq (-1), which is both negative and statistically significant at 1%, providing further evidence of cointegration among the variables. The speed of adjustment indicates the pace at which a variable return to its equilibrium level following a shock, and in this case, the value is -0.407.

The residual equation is CointEq = In_Y – (-0.176*In_OilP + 0.952*In_L + 3.153*In_K – 1.930*In_Land – 15.730).

Meaning, the residual or error term is the observed (In_Y) minus the estimated (-0.176*In_OilP + 0.952*In_L + 3.153*In_K – 1.930*In_Land – 15.730).

5.1 Summary

The following were the findings with respect to the control variables and objectives:

- Agricultural employment per total employment and agriculture machinery and tractors were both found to be positively correlated with agricultural value added per GDP
- The agricultural land per total land was insignificant in influencing agriculture output.

- The international brent crude oil prices show that, between 1980 to 2020, the highest price was 111.63 dollars per barrel which occurred in 2012, and the lowest price was witnessed in 1998, which was 12.76 dollars per barrel.

5.2 Conclusion

Based on the findings, the study concludes that, short and long-run relationship exist between international crude oil prices and the agriculture value added per GDP. Short and long run relationship also exist among the agriculture labor (agriculture employment per total employment), agricultural capital (agricultural machinery and tractors) and agriculture value added per GDP.

Again, the study also concludes that crude oil consumption pattern in the agriculture sector and the whole economy largely increases annually from 2000 to 2021.

5.3 Recommendations

Given the observed negative relationship between international crude oil prices and agricultural output, it is imperative to formulate policies that mitigate the adverse impacts on the agricultural sector. Invest in research and development initiatives focused on creating drought-resistant and oil-price-resistant crop varieties. Develop agricultural technologies that can thrive under varying economic conditions, reducing the vulnerability of the sector to external shocks. Provide training and capacity-building programs for farmers to enhance their adaptability to changing economic conditions. Equip them with knowledge and skills to implement innovative and resilient agricultural practices. Establish monitoring systems and early warning mechanisms to track trends in crude oil prices and their potential impact on agriculture. This allows for proactive policy adjustments and timely interventions to mitigate negative effects.

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Abbreviation

ARDL; Autoregressive Distributed Lag
EIA: Energy Information Administration
GDP: Gross Domestic Product
WDI: World Development Indicator