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Determination of Fertilizer Cost Components and Their Effect on Fertilizer Prices and the Fertilizer Value Chain in Ghana

IFDC FERARI Research Report No. 4

N. Odionye, D. Saa, A. Laamari, W. Adzawla, I., Koffi, E. Afimia, W.K. Atakora, M. Jemo, P.S Bindraban



Determination of Fertilizer Cost Components and Their Effect on Fertilizer Prices and the Fertilizer Value Chain in Ghana

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This report is based on the thesis by N. Odionye, submitted to the Faculty of the School of Agriculture, Fertilization and Environmental Sciences (ESAFE) for obtaining the diploma of master's degree in "Fertilizer Science and Technology." This thesis research was conducted under the [Fertilizer Research and Responsible Implementation \(FERARI\)](#) program.

Citation:

Odionye N., Saa D., Laamari A., Adzawla W., Koffi I., Afimia E., Atakora W.K., Jemo M., Bindraban P.S., 2020. Determination of fertilizer cost components and their effect on fertilizer prices and the fertilizer value chain in Ghana. IFDC FERARI Research Report No. 4.

ACKNOWLEDGMENTS

Acknowledgements by Nnaemeka Odionye from his thesis.

I would like to thank my family for their support throughout my master's program. Also, I would like to thank my supervisors, co-supervisors, and the entire IFDC staff for their hospitality and professionalism in guiding me through all the steps necessary in delivering this report. Finally, I would like to thank the School of Agriculture, Fertilization and Environmental Sciences (ESAFE) faculty members, UM6P lecturers, and students for their hospitality and OCP Foundation for the scholarship they provided for this master's program.

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ABBREVIATIONS

ADF	Augmented Dickey-Fuller
AFO	AfricaFertilizer.org
AIC	Akaike Info Criterion
ARDL	Autoregressive Distributed Lag
C.V.	Critical Value
CNPK	Commercial Nitrogen, Phosphate, and Potassium
COVID-19	Coronavirus Disease 2019
CUREA	Commercial Urea
ECM	Error Correction Model
FAO	Food and Agricultural Organization of the United Nations
FMC	Forward Market Commission
FOB	Free on Board
FOT	Free on Truck
FPE	Final Prediction Error
FSP	Fertilizer Subsidy Program
GDP	Gross Domestic Product
GFEP	Ghana Fertilizer Expansion Program
GoG	Government of Ghana
GSS	Ghana Statistical Service
ha	hectares
HQ	Hannan-Quinn
ICT	Information and Communication Technology
IFDC	International Fertilizer Development Center
KASO	Kasoa Market
KOFO	Koforidua Market
LR	Likelihood Ratio
MANK	Mankessim Market
MCDM	Multi-Criterion Decision-Making
MoFA	Ministry of Food and Agriculture
mt	Metric Ton
NPK	Nitrogen, Phosphate, and Potassium
OLS	Ordinary Least Square
PBM	Parity Bound Model
PFJ	Planting for Food and Jobs
PP	Phillips-Perron
SEB	Security Exchange Board
SECK	Seckondi Market
SEECM	Single Equation Error Correction Model
SNPK	Subsidized NPK
SoA	Ammonium Sulfate
SUREA	Subsidized Urea

TAKO	Takoradi Market
TECH	Techiman Market
U.S.	United States
USD	United States Dollars
VAR	Vector Autoregression
VCR	Value:Cost Ratio
VECM	Vector Error Correction Model
WENC	Wenchi Market

ABSTRACT

Fertilizer is a major input for crop production, especially in nutrient-depleted soils. In Ghana, consumption of fertilizers has been relatively low due to high prices, which has prompted the introduction of fertilizer subsidy programs to induce consumption and increase agricultural productivity. However, the externality effect of the subsidy program is eroding the profitability of the fertilizer sector downstream, especially the commercial fertilizer market, as margins are insufficient to encourage the expansion of retail distribution networks to remote agrarian communities. These externalities could compromise the gains made by the Planting for Food and Jobs (PFJ) program of the Government of Ghana (GoG).

This study establishes margins and profitability of value chain actors in the wake of the PFJ. A total of 394 respondents, comprising 153 agro-dealers (106 retailers, 42 distributors, and five importers) and 241 farmers, were interviewed through the aid of a questionnaire. Cointegration analyses were used to investigate price transmission within markets, while a vector auto regression (VAR) model was used to determine the relationship between subsidized and commercial fertilizers (NPK 15:15:15 and urea) for the period 2012-2019.

The results revealed weak market efficiency within the fertilizer markets investigated in Ghana while also establishing that prevailing prices of subsidized fertilizers influence the subsequent prices of commercial fertilizers for the period investigated. Furthermore, value chain cost and margin breakdown revealed fertilizer importers had a net positive margin (6.24%) when all costs were factored in, while distributors and retailers had net margins of -17.19% and -15.13%, respectively, for commercial urea. Farmers had the highest transportation cost (3 GHC per 50-kg bag) associated with the purchase of fertilizers, as a result of the poor fertilizer distribution network in Ghana. The report concludes with several recommendations, such as an inclusive subsidy negotiation and more research and development to address the identified externalities.

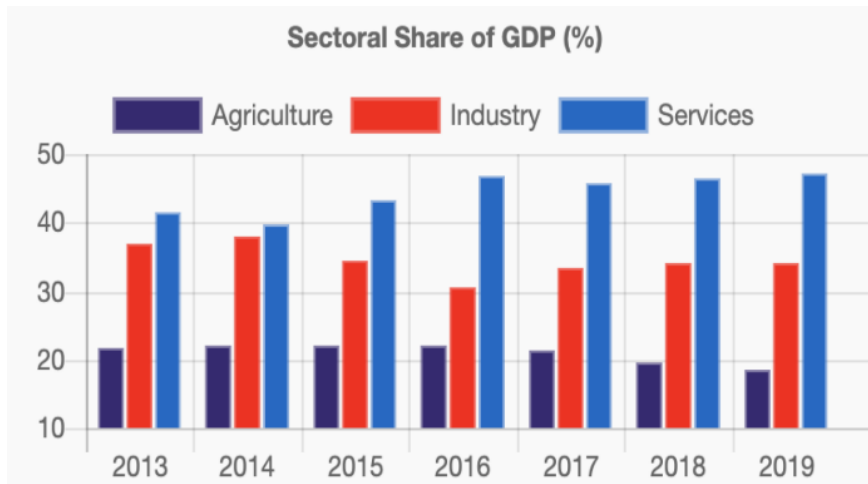
Keywords: Fertilizer value chain; fertilizer cost components; fertilizer price transmission; market integration; market inefficiency

CHAPTER 1: INTRODUCTION

1.1 Ghana and Agriculture

Ghana has a population of over 29.7 million people and a gross domestic product (GDP) of \$65.46 billion (World Bank, 2020). In 2019, the agriculture sector contributed 18.5% to Ghana's GDP (GSS, 2020), as shown in Figure 1, and employed 52% of the total labor force (FAO, 2020). Furthermore, it is a major source of foreign exchange, which is substantiated by Ghana's ranking as the second biggest cocoa exporter behind Côte d'Ivoire. Export crops occupy 60% of total cultivated area and consume 51% of total fertilizers, while staple crops occupy 40% of total cultivated area and consume 49% of total fertilizers (Fuentes et al., 2011; GFEP, 2018). Ghana constitutes about 10.6% of the Economic Community of West African States (ECOWAS) fertilizer market share, with an annual fertilizer consumption of 440,661 metric tons (mt) and 310,866 mt in 2017 and 2018, respectively, and is the region's third biggest fertilizer market after Nigeria and Mali (AFO, 2020).

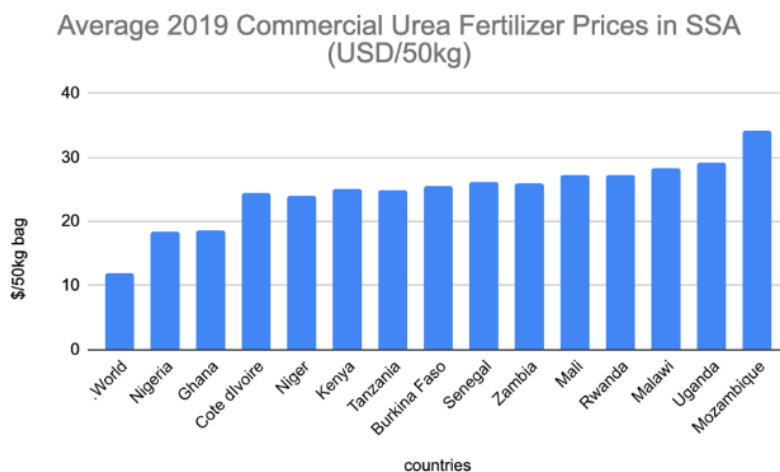
Due to the importance of agriculture in job creation and rural development, the Government of Ghana (GoG) has substantially invested in agricultural projects over the years. These projects include the Ghana Grains Development Project (1979-1997) and the Food Crops Development Project (2000-2008). Despite gains made by previous programs in the sector, the shortfalls of globalization were evident as effects of the 2008 global economic meltdown rippled across countries and continents. The agriculture sector was not spared as food prices soared. To enhance food security in line with the *Abuja Declaration on Fertilizer for an African Green Revolution*, the GoG introduced a Fertilizer Subsidy Program (FSP) in 2008 that was rolled out in 2009 (Fuentes et al., 2011). This ushered in a new era of FSP in Ghana and across sub-Saharan Africa (SSA). In 2017, the new administration in Ghana introduced a program called Planting for Food and Jobs (PFJ), with the objective of increasing agricultural productivity and creating employment opportunities within the sector. One of the pillars of the PFJ program is to provide fertilizers at 50% subsidy, targeted to smallholder farmers with 0.4-2 hectares (ha) of land and cultivating important staple crops (MoFA, 2017; Wiredu et al., 2019; Scheiterle et al., 2019; IFDC, 2019; Iddrisu et al., 2020).



Source: GSS, 2020.

Figure 1. Sectoral contribution to GDP in Ghana

In general, Ghana's FSP has successfully increased its domestic fertilizer consumption from 137,000 mt in 2006 to 425,110 mt in 2019 (AFO, 2020). The 2019 PFJ subsidized fertilizer prices were 12 USD/50 kg and 13 USD/50 kg for urea and NPK, respectively, while commercial fertilizer prices for the same period were around 19 USD/50 kg and 20 USD/50 kg for urea and NPK, respectively. Ghana fertilizer prices are the lowest in the region alongside Nigeria, as revealed in Figure 2 (AFO, 2020). Despite gains made by the FSP, the subsidy program has resulted in market distortion and market inefficiencies, including smuggling, uneven margins, and poor fertilizer market development. Bonilla et al. (2020) observed that fertilizer prices are lower in Northern Ghana as compared to Southern Ghana, which is an entry point for fertilizers as all the ports are located in the South. Low fertilizer prices farther north violate the law of one price, which stipulates the existence of a universal price for a defined commodity no matter the market as long as it has been adjusted for transaction costs and other associated taxes/levies (Baffes, 1991). It is also speculated that commercial fertilizer prices are kept as close as possible to subsidized fertilizer prices to remain competitive in the wake of the FSP. These low margins act as disincentives for the development of local distribution networks (IFDC, 2019), as actors claim commercial fertilizers are sold only to increase cash flow and maintain their existing customers. At the last rung of the fertilizer value chain, farmers are not left out and would have to travel long distances to acquire fertilizers due to the lack of local fertilizer retail outlets. The lack of local fertilizer retail networks acts as a disincentive for fertilizer use by farmers, as depicted by Obisesan et al. (2013). Furthermore, farmers are often faced with constraints, such as access to finance, asymmetric information, and fluctuating commodity prices, which exacerbates the entire process of fertilizer acquisition (Klutse et al., 2018). Previous studies by Fuentes et al. (2011) and IFDC (2019) revealed that financial cost is the biggest cost component associated with final fertilizer retail prices; however, the effects of cost components on market margins were not established. Also, the level of spatial fertilizer market integration is unknown, which is an important parameter in understanding the movement of fertilizer from surplus markets to deficit markets.



Source: IFDC, 2019.

Figure 2. Average retail fertilizer price in SSA

1.2 Research Questions

1. What are the costs and margins associated with commercial and subsidized fertilizers along the fertilizer value chain in Ghana?
2. How effective are fertilizer prices transmitted spatially in markets within Ghana?
3. What relationships exist between commercial and subsidized fertilizer prices in Ghana?

1.3 Objective of Research

The overall objective of this research is to determine the level of efficiency, distribution of costs, and margins in each segment of Ghana's fertilizer value chain and the effect of several cost components on stakeholder margins in the chain. The specific objectives are outlined below:

1. Assess fertilizer cost components and margins associated with stakeholders in each stratum of the value chain.
2. Determine the level of market integration in Ghana.
3. Determine the relationship between commercial and subsidized fertilizer prices.

1.4 Hypotheses

Ho. Stakeholder margins are below the Bank of Ghana's 365-day treasury bill rate.

Ho. Ghana's fertilizer market is not spatially integrated.

Ho. Commercial urea fertilizer price cause subsidized urea fertilizer price.

1.5 Scope and Limitation of Study

The scope of the study is to evaluate the level of efficiency within Ghana's fertilizer market and to give a breakdown of various cost components and their effect on stakeholders' margin. Cost components for the seven fertilizers captured under the PFJ and ammonium sulfate (SoA) are

investigated in the major agricultural communities within the Savannah agroecological zone because of the region's role as the major food basket in Ghana.

Due to limited data on fertilizer market prices, spatial market integration analyses were conducted based on the price of NPK 15:15:15 from major markets in the Southern part of Ghana. Furthermore, due to restrictions caused by the COVID-19 pandemic, surveys were limited to urban and peri-urban communities.

1.6 Justification of Study

The essence of this study is to provide empirical evidence to inform policymakers and fertilizer stakeholders on Ghana's fertilizer spatial price transmission and the effects of market constraints on the final fertilizer price. This would enable the GoG and other allied institutions to provide appropriate policies to develop the domestic fertilizer market and incentivize more private sector involvement in the sector.

CHAPTER 2: LITERATURE REVIEW

2.1 Ghana Fertilizer Trend

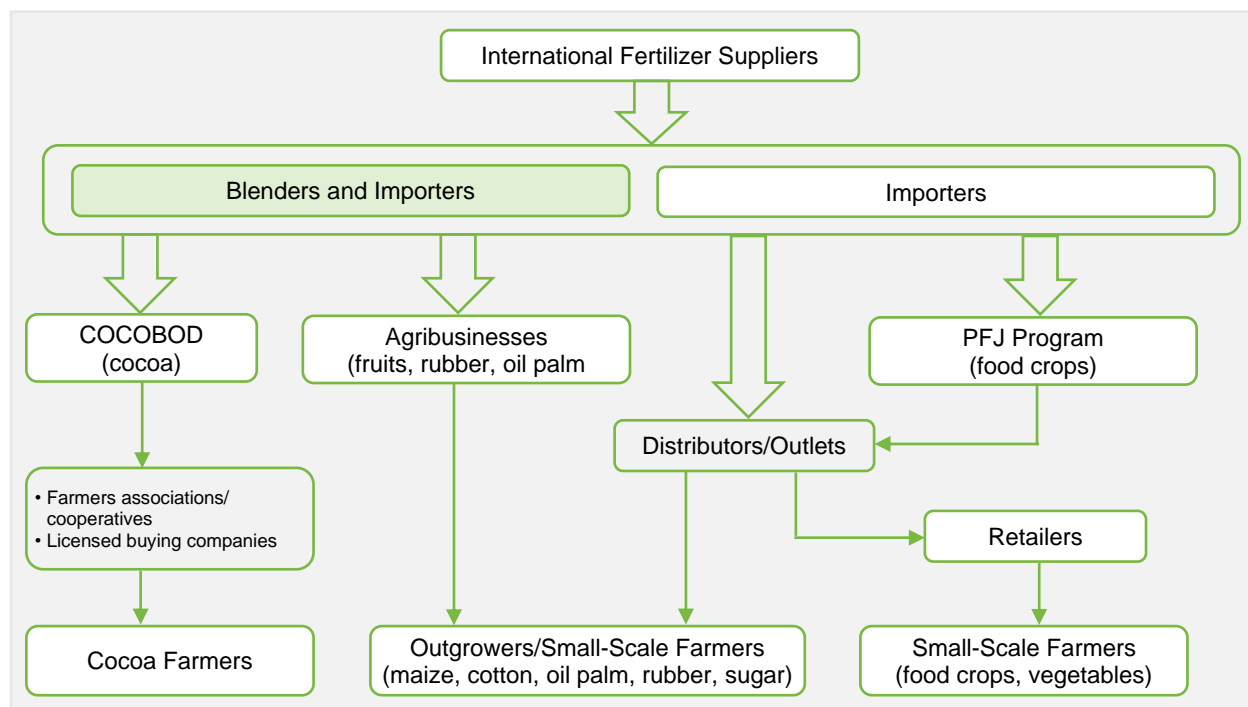
Ghana imports all its fertilizers with little domestic value addition in the form of blending. Pre-1980s, the total amount of fertilizers imported was below 60,000 mt per annum. Macroeconomic reforms in the 1980s made foreign exchange scarce, which led to currency devaluation; the effect of a devalued currency meant more money was needed to import same amount of goods and services. Faced with limited foreign currency and competing needs, the GoG eliminated FSPs. The effect was felt by farmers as fertilizer demand declined, which led to a spike in food prices (Jayne et al., 2003). The 1990s saw a rise in importation to 56,000 mt and a peak in 2003 at 93,000 mt, with a further decline to 56,000 mt in 2004; in 2006, it increased to 137,000 mt (Fuentes et al., 2011).

The 2008 global financial meltdown took a toll on Ghana's economy, as total fertilizer imports declined by 10%. In 2009, the GoG reintroduced fertilizer subsidies to cushion the effect of the financial crisis. The new subsidy program incorporated the use of coupons to target smallholder farmers and specific crops of interest. The effect of the subsidy program was instant, as total fertilizer imports increased to 218,000 mt (Fuentes et al., 2011). In order to create employment, reduce poverty, and increase agricultural productivity, the GoG introduced the PFJ program with a 50% subsidy rate for fertilizer in 2017 (MoFA, 2017; Ansah et al., 2020). The PFJ has five key components comprising seed promotion, fertilizer access, extension services, market development, and information and communication technology (ICT) (MoFA, 2017; FTWG, 2019). The PFJ's 50% FSP is the highest within the ECOWAS region, and the effect was an eminent increase in apparent fertilizer consumption (440,661 mt) in 2018 (AFO, 2020). Fluctuations in the domestic fertilizer market are attributed to the absence of local fertilizer production, which has left Ghana vulnerable to international commodity price shocks, especially when considering the small size of the market.

2.2 Fertilizer Distribution Channel

All imported fertilizers in Ghana are distributed to farmers through one of three of differentiated channels shown in Figure 3: (a) plantations and commercial/industrialized crops owners; (b) agricultural parastatals, such as PFJ and COCOBOD; and (c) smallholder farmers and producers of staple food crops. The plantations owners have large-scale farms for cultivating cash crops, such as sugarcane, oil palm, tobacco, and rubber. Due to their reliance on fertilizer for productivity and profitability, they import and distribute fertilizers to selected interest groups, such as outgrowers, under a contractual agreement to buy back output at a guaranteed price. Recently, due to logistics, limited financial resources, and time constraints, most plantations have abandoned fertilizer importation, leaving it to in-country importers, while maintaining their local distribution networks (IFDC, 2019). The GoG established COCOBOD as a government agency in 1947 to regulate the cocoa industry in order to increase value addition and generate foreign exchange. COCOBOD is responsible for the facilitation of production and processing of cocoa, coffee, and shea. It is also charged with the responsibility of formulating policies within the cocoa sub-sector. COCOBOD was responsible for fertilizer importation and distribution through its network of over 90% of cocoa farmers. Subsequent fertilizer market reforms made COCOBOD exit importation

operations, leaving importation to private sector players, such as Yara-Wienco and Chemico. PFJ also distributes fertilizers to targeted farmers under the GoG subsidy program. Smallholder farmers not captured by the FSP rely on the open market for their fertilizer needs at commercial prices.



Source: AFO, 2020.

Figure 3. Fertilizer distribution channels in Ghana

2.3 Fertilizer Supply Chain Cost Analysis

Ghana relies solely on fertilizer importation; therefore, the fertilizer cost structure is divided into international and domestic cost. Importation cost is determined by international free on board (FOB) price, and domestic costs are influenced mainly by infrastructure, policies, and macroeconomic conditions (Fuentes et al., 2011). FOB prices are often controlled by global energy prices (Huang, 2009; Ripplinger and Miljkovic, 2017) and are beyond the control of any country. Domestic supply chain costs remain under the domain and influence of GoG. Hence, from an in-country perspective, cost analysis is premised on the domestic supply chain components. As shown in Table 1, the 2018 free on truck (FOT) cost of urea at the port of Tema was \$394.20/mt; FOB was the highest cost constituent with 70.5% of total FOT bagged cost, followed by ports/shipping cost with 10%; insurance/freight, bagging, and tariffs/levies were 9.2%, 5.8%, and 5.3%, respectively. In summary, there is an additional 29.5% cost from FOB to FOT at the port level. Further costs are incurred along the value chain, as fertilizers are transported geographically and also vertically down the value chain, in the form of storage and financial costs.

Table 1. FOT cost of importing urea at Tema port

Importer Costs/Charges	\$/mt	GHC/mt	FOT Bulk %	FOT Bagged %
------------------------	-------	--------	------------	--------------

FOB	279.40	1,341.10	74.8%	70.5%
Cost, Insurance, and Freight	305.10	1,464.30	81.7%	77.0%
Total Taxes, Tariffs, and Levies	326.10	1,565.10	87.3%	82.3%
Port Charges	365.10	1,753.80	97.8%	92.2%
Shipping Charges	366.10	1,754.80	97.9%	92.3%
Total Forwarder Charges	371.20	1,778.60	100%	94.2%
FOT Cost at Port of Tema	371.40	1,793.30	100%	94.2%
Bagging	394.20	1,902.30		100%
Total FOT Bagged at Tema Port	394.20	1,902.30		100%

Note: Assumed exchange rate is GHC 4.8/\$1, three-month average, up to September 2018.

Source: IFDC, 2019.

2.4 Identifying Key Constraints and Bottlenecks

2.4.1 High Cost and Inefficiencies at the Port

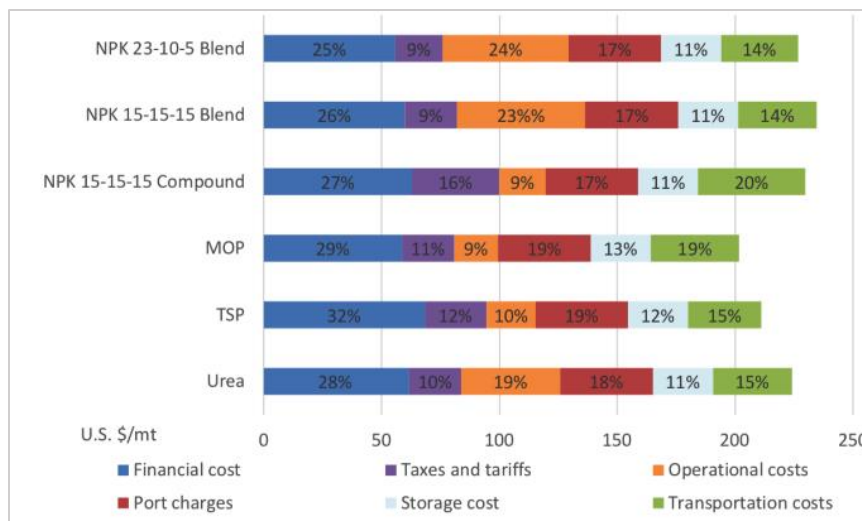
A plethora of operational inefficiencies, such as the exclusive regulation that permits only port employees (stevedores) to perform the loading and bagging of products, exist at the ports that culminate into the high cost of fertilizers; these often slow down the process and lead to additional demurrage (Fuentes et al., 2011). Limitations in port capacity and infrastructure further exacerbate the entire process. According to Fuentes et al. (2011), the port cost could be reduced if the exclusive rights to the stevedores was reversed and made competitive. Furthermore, the labor cost for unloading and bagging, which is pre-established by the port authority at an hourly cost, is not reflective of competitive market rates and does not provide enough incentive for workers to increase their productivity. Also, shallow drafts prevent the docking of vessels larger than 15,000 mt, hence eliminating the potential for economies of scale.

2.4.2 Uneven Distribution of Market Margins

The newly introduced FSP price negotiation only involves importers (IFDC, 2019). The exclusion of distributors and other downstream players has led to market distortion, and margins are unevenly distributed among actors. Negotiation leaves the importers better off when they hedge against international price fluctuation, currency devaluation, and high-interest rates. Distributors take whatever price is offered by importers and, in most cases, are responsible for the transportation of these fertilizers to the point of sale. Distributors are also faced with harsh macroeconomic conditions, such as high domestic interest rates, currency devaluation, and other risks associated with fertilizer logistics (Fuentes et al., 2011; IFDC, 2019). Furthermore, the same burden is passed down from distributors to retailers, who in most cases face harsher conditions, such as poor access to credit associated with over-collateralization of loans and high-interest rates. The FSP price capping erodes whatever profit margins that would have been made in a competitive market. Therefore, the entire system does not induce value chain actors to expand their distribution networks into the most remote parts of Ghana.

2.4.3 Financial Constraint

Access to credit is a challenge to domestic fertilizer distributors and retailers; loan over collateralization makes it difficult for downstream players to access credit. In situations where credit is available, it is mostly given out at an exorbitant interest rate of 30-35% per annum. Hence, for businesses to write off their debts, they would require a profit margin higher than 30-35% (Fuentes et al., 2011). IFDC (2019) also confirmed high financial cost is a major contributor to the high margins in fertilizer retail prices and requires urgent intervention, as depicted in Figure 4. Fuentes et al. (2011) stated that fertilizer distributors and retailers face the same credit constraints as farmers as a result of lenders' perceived risk and uncertainty in agricultural businesses. Generally, financial institutions prefer to invest in low-risk government bonds with higher returns rather than increasing their agricultural loan portfolio.



Source: IFDC, 2019.

Figure 4. Fertilizer importers cost breakdown in Ghana

2.4.4 Poor Infrastructure

Poor road networks and a lack of rail services in transporting fertilizers to farming communities also influence fertilizer pricing and adoption by farmers, especially in isolated communities. This is substantiated by higher retail fertilizer prices in remote regions, as revealed in Table 2. The distance to fertilizer retail shops or cost of transportation influences a farmer's decision to use fertilizer, as they often would have to travel a long distance to purchase them (Fuentes et al., 2011; Obisesan et al., 2013).

Table 2. 2009 fertilizer price and coupon value in Ghana

Region	Fertilizer Product and Prices							
	Urea		AS		N-P-K/T-15		N-P-K Blend	
	Market Price	Coupon Value*	Market Price	Coupon Value*	Market Price	Coupon Value*	Market Price	Coupon Value*
	(US \$/50-kg bag)							
Northern	27.88	9.20	23.56	10.60	38.87	20.60	36.23	19.20
Upper East	28.29	9.90	24.26	11.40	40.38	21.40	36.85	19.90
Upper West	27.65	9.40	23.48	10.80	39.25	20.80	36.60	19.40
Central	26.77	8.30	22.79	9.80	38.08	19.80	35.19	18.30
Eastern	27.81	8.90	23.41	10.30	39.04	20.30	36.35	18.90
Brong Ahafo	27.81	8.90	23.41	10.30	39.04	20.30	36.35	18.90
Western	26.88	8.60	22.95	10.10	38.65	20.10	35.77	18.60
Greater Accra	26.33	7.90	22.38	9.40	38.04	19.40	35.10	17.90
Volta	27.81	8.90	23.11	10.40	39.23	20.40	36.35	18.90
Ashanti	27.10	8.40	23.02	9.90	38.27	19.90	35.38	18.40
Averages	27.50	8.80	23.41	10.30	39.04	20.30	36.15	18.80

*The exchange rate considered for estimating the coupon value and the product price is 1.4 GHC to US \$1.00.

Source: IFDC, 2019.

2.4.5 Underdeveloped Fertilizer Market and Low Fertilizer Demand

The incorporation of coupons for subsidy in the new FSP is intended to help the program achieve its objective of targeting smallholder farmers (0.4-2 ha) and specific crops. However, the use of these coupons simply means the fertilizer market is defined and disincentivizes the expansion of retail and distribution networks to remote areas in order to capture more farmers. Houssou et al. (2017) revealed that fertilizer subsidies can crowd out private sector activities in areas with well-developed distribution channels. Furthermore, low crop productivity, attributed to blanket recommendations, lack of extension services, and farmers' technical know-how, is responsible for low fertilizer productivity, which has reduced the volume of fertilizer demand in Ghana (Fuentes et al., 2011; IFDC, 2019). For retailers to be profitable and remain in business, they must increase their margin to make up for the volume deficit, since revenue is a function of price and quantity.

In summary, Figure 4 highlights the various constraints in Ghana's fertilizer value chain pertaining to fertilizer costs and prices.

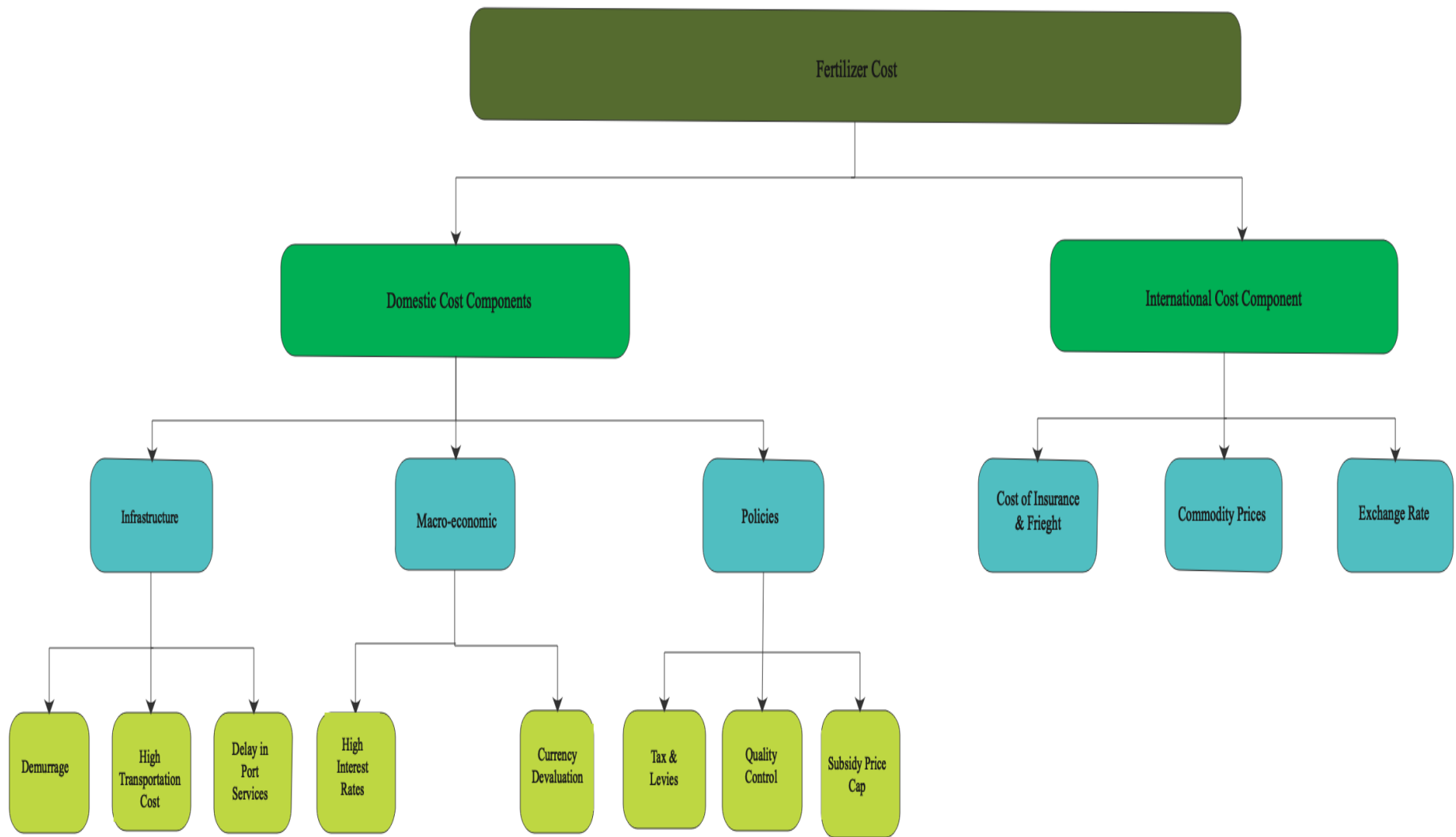


Figure 4. Problem tree associated with the fertilizer value chain in Ghana

2.5 Empirical Review

Most agricultural market integration studies have focused on agricultural commodity prices. For instance, Galang (2014) examined the spatial fertilizer market in the Philippines through cointegration analyses and established that prices in regional markets cause or influence prices in other markets. This indicates market integration, whereby shocks in one market would ripple across other markets. The author explained that causal determination was essential in identifying price leaders and price takers in the region. Also, Rufino (2008) studied the existence of partial market integration in the Philippine rice market. The presence of stationarity was determined through an Augmented Dickey-Fuller (ADF) test, while Engel Granger cointegration and Granger causality tests were used to determine long-run and causal relationships. The study concluded that market price transmission was efficient despite the existence of market segregation and poor distribution networks.

Gupta et al. (2018) and Inan (2018) investigated market efficiency and price discovery in India's agricultural commodity market. They utilized a unit root analysis to investigate whether price series exhibited random walk, while Johansen cointegration was used to assert the existence of a long-run relationship. Mohanty and Mishra (2020) also investigated the impact of Indian regulatory reform and market efficiency on domestic agricultural commodity markets through intraday prices (pre-merger and post-merger) between the Forwarding Market Commission (FMC) and Securities Exchange Board (SEB). The study utilized an intraday predictability return model based on past order flows via Ordinary Least Square (OLS), in line with Rosch et al. (2017), and a multiple various ratio test to evaluate weak market efficiency. The investigation revealed the presence of short-term inefficiency during the pre- and post-merger period. Furthermore, Baquedano and Liefert (2014) utilized a Single Equation Error Correction Model (SEECM) to investigate market integration and price transmission in developing countries. SEECM, unlike the Error Correction Model (ECM), does not necessarily require the presence of unit root to determine the long-run relationship of a time series.

In the global North, Daly et al. (2017) utilized ADF and Johansen cointegration tests to determine the long-run relationship between corn, fertilizer, and natural gas spot prices in the United States (U.S.), while VECM was used to re-estimate the relationship among ammonia, natural gas, and corn prices. Hu and Brorsen (2017) investigated spatial transmission of urea prices in the U.S.; the study utilized a VECM and a Parity Bound Model (PBM), as outlined by Baulch (1997). PBM was introduced by Baulch (1997) as a more accurate procedure to test for spatial price transmission when the cost of transaction data is available.

There also have been numerous investigations on market integration in Africa, especially on commodity market prices. Delgado (1986) utilized a variance component model to evaluate 18 months of weekly grain prices from 22 villages in Northern Nigeria, which revealed the absence of market integration. In Kenya, Gitau and Meyer (2018) studied the spatial linkages in maize markets (surplus and deficit) in the presence of transaction cost and policy interventions through a cointegration and a causality test. The study revealed close market pairs were integrated, which could be a result of low transaction costs; therefore, price differences were easily adjusted as compared to further isolated markets with high transaction cost. Zungol and Kilima (2019) investigated the price transmission between maize and rice prices in Tanzania (1987-2012) with a cointegration analysis; the study revealed a long-term relationship existed between maize and rice prices for the period observed.

Previous studies on the fertilizer market had focused on the demand side; Manos et al. (2007) investigated the effect of fertilizer price policy on farm behaviors such as income and employment through a Multi-Criterion Decision-making Model (MCDM) in Bangladesh. A utility function was used to analyze farmers' behavior under alternative fertilizer prices while trying to maximize gross margin and minimize variance of gross margin and labor. Their findings revealed that minimization of labor was significantly higher than others, which implies that, in the wake of higher fertilizer prices, farmers are more inclined to cut down on farm labor or switch to less labor-intensive crops to maximize their utility function. Chakraborty (2016) investigated the determinants of fertilizer demand in India. He utilized time series data and estimated a demand function for fertilizer through an OLS regression model. He revealed that non-price factors are more important than the price of fertilizers in determining fertilizer use by farmers. Investigation to understand the supply and demand for nitrogen fertilizers among smallholder farmers in Malawi was conducted through a two-step procedure in which a Hicksian and Marshallian price elasticity were estimated. The findings revealed that fertilizer price and agricultural commodities, such as maize and tobacco, were crucial for farmers in making fertilizer decisions (Chembezi, 1990). Huang (2009) further identified energy cost, transportation cost, feedstock cost, exchange rate, unions, and the number of industry participants as the major factors responsible for supply-side fertilizer price variation. Meanwhile, factors that affect fertilizer prices from the demand side include population, economic growth, foreign trade policies, commodity prices, and the presence or absence of subsidies.

Rashid et al. (2014) assessed fertilizer policies, value chain, and profitability in Ethiopia, and the findings revealed that specific household characteristics, such as geographic location, entrepreneurial skills, access to market, and credit availability, influence demand for fertilizer. Furthermore, fertilizer profitability to farmers is a function of value:cost ratio (VCR), and a high VCR of at least 2 is needed for fertilizer use to be profitable in Africa. Petrick and Latruffe (2003) investigated Polish farmers' credit access and borrowing cost through a hedonic pricing model to estimate the effect of various loan attributes and their impact on financial cost. This revealed that young farm owners with updated bookkeeping practices had a higher likelihood of accessing loans while household size also influenced the amount of loan applied by farmers, as these tend to smoothen consumption. Although these studies provided a guide to understand the fertilizer value chain, empirical evidence that examines the fertilizer value chain of Ghana with analysis of the market integration possibilities is limited.

2.6 Theoretical Review

2.6.1 Market Efficiency

A market can be defined quantitatively or qualitatively (Carlton, 2007), but for this research, a market is defined as a platform where goods and services are traded. An efficient market is a market in which all costs and benefits are reflected in the commodity price. The absence of this condition can lead to market failure, as a result of the presence of externalities, asymmetric information, and lack of market competition (Dowding and Taylor, 2020). Externality, information asymmetry, and noncompetitive markets are inextricably linked, and they affect the transaction cost of products when left unregulated. It is, therefore, imperative for governments, policymakers, and private sector actors to understand the concept of agricultural market efficiency due to the sensitive nature of the sector and its macroeconomic impact, especially in SSA.

Market efficiency is divided into: (a) weak efficiency, which occurs when commodity prices reflect all publicly captured information; (b) medium efficiency, when commodity prices adjust to prevalent market information as quickly as possible, thereby eliminating the possibility of abnormal profit; and (c) strong efficiency, when all private and public information is captured in the commodity (Mohanty and Mishra, 2020).

2.6.2 Market Integration

Market integration is defined by Barrett (1996) as the movement of goods and underlying information, such as price, over time, space, and form. It emphasizes the traceability of goods from one market to another (Rapsomanikis et al., 2006; Barrett, 2008). It is on this premise that arbitrageurs move goods from surplus markets to deficit markets (Balch, 1997), which also ensures the stability of market prices. Galang and Myka (2014) indicated that market integration is a necessary but not sufficient condition for an efficient market, as other factors that characterize a perfectly competitive market need to be in place. Hence, market integration can be used to understand the level of competitiveness in a market (Rufino, 2008). Recently, market integration has been an area of interest for governments and development organizations, especially in developing countries. It provides a basis to understand the depth and spread of policies and market shocks within a value chain or across regional markets. Therefore, information on market integration may provide specific evidence on the extent of the competitiveness of a market (Alexander and Wyeth, 1994).

2.6.3 Law of One Price

The law of one price is predicated on the assumption that there is a prevailing market price for a homogenous commodity at every point in time, as long as it has been adjusted for all transaction costs, such as transportation and tariffs (Baffes, 1991; Lutz et al., 1995; Baquedano and Liefert, 2014; Hu and Brorsen, 2017). It is on this principle that the Big Mac Index was invented as an unofficial measurement of real exchange rate when all other factors have been factored in. For instance, Richardson's (1978) model on commodity arbitrage between U.S. and Canada was modified by Fackler and Godwin (2001) in a bivariate linear model, as indicated below:

$$P_{it} = \beta_0 + \beta_1 P_{jt} + e_t \quad (1)$$

P_i is the price of a homogenous commodity at a point in time (t), P_j is the price of the same commodity in another market at the same time (t), while β_0 is the intercept, β_1 and e_t are the coefficient of regression and the error term, respectively. When $\beta_0 = 0$ and $\beta_1 = 1$, both are assumed to be perfectly integrated as they exhibit perfect price transmission.

CHAPTER 3: EMPIRICAL METHODOLOGY

3.1 Data

The study utilized primary and secondary data to investigate the objectives outlined. Primary data for Objective 1 was obtained through the administration of questionnaires to farmers, retailers, and distributors in urban and peri-urban communities within Kumasi, Tamale, Yendi, Techiman, Wa, Kintampo, Walewale, and Bolgatanga; importers were interviewed in Greater Accra, which is the point of entry for most fertilizers consumed in Ghana. Secondary data for Objectives 2 and 3, such as FOB prices, average national fertilizer prices, and local fertilizer market prices, were obtained from IFDC, AfricaFertilizer.org (AFO), MoFA, and Esoko for the period 2012-2019.

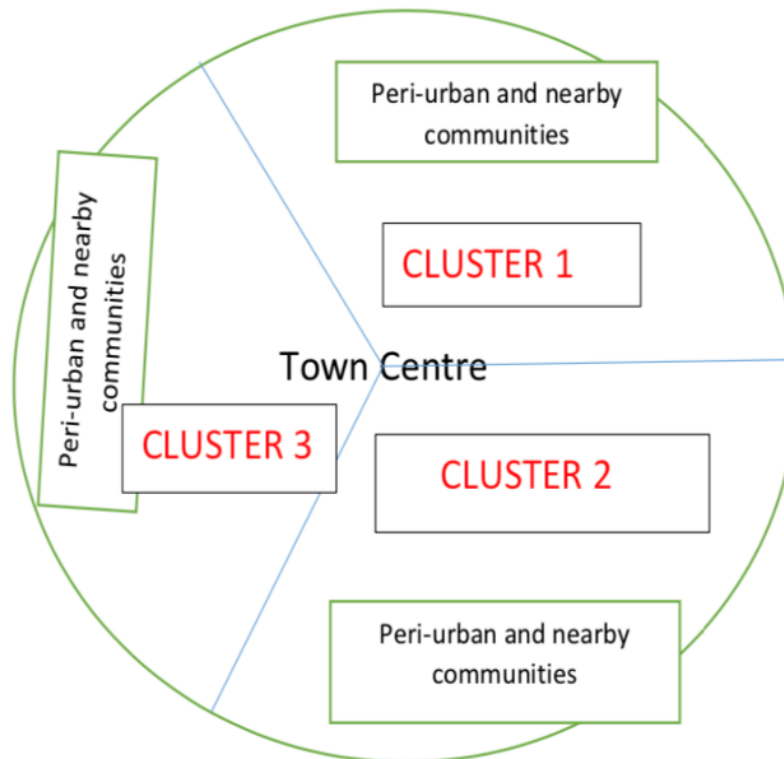


Figure 5. Sampling technique in each surveyed community

Based on Figure 5, seven retailers, three distributors, and 10 farmers were selected from each cluster by snowballing, due to COVID-19 restrictions, totaling 10 agro-dealers and 10 farmers per community. The survey regions (Greater Accra, Ashanti, Bono, Northern, North-East, and Upper-West region), highlighted in Figure 6 were selected by purposeful sampling, in line with Maxwell (1996). Prices were collected for the seven PFJ fertilizers and SoA (a non-PFJ fertilizer). Greater Accra and Ashanti regions are major fertilizer supply routes, as most fertilizers in Ghana are imported through the port of Tema, while Bono, Northern, North-East, and Upper-West regions, which are agricultural communities and consume a substantial amount of the national fertilizer quota in Ghana, make up the Guinea Savannah agroecological zone. Price transmission for NPK

15:15:15 within markets was investigated in Kasoa, Koforidua, Takoradi, Techiman, Mankessim, Seckondi, and Wench due to data availability.

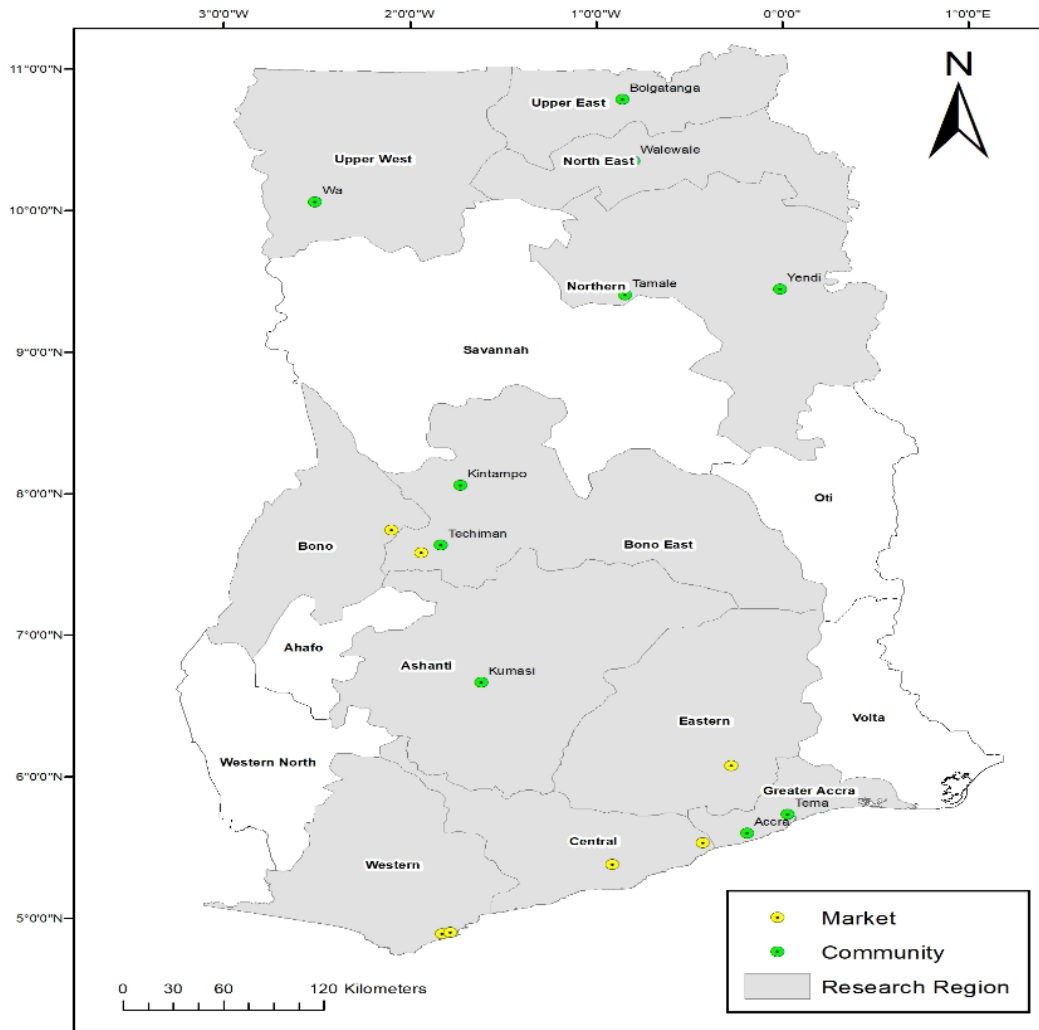


Figure 6. Study regions in Ghana

3.2 Data Analysis

3.2.1 Unit Root

Most time-series data possess unit root (non-stationarity), which makes the time series unfit for stochastic analysis. The absence of unit root, also known as stationarity, indicates that: (a) time series data is mean revolving or has a constant mean: $\mu(t) = \mu$; (b) the variance of the distribution is constant over time: $\sigma^2(t) = \sigma^2$; and (c) the time series distribution is not dependent on time (Priebe, 2019). Hence, if all of these conditions are violated, the series is said to be non-stationary and is likely to produce a spurious result when utilized for statistical analysis without correction (Obayelu and Salau, 2010; Mahmood et al., 2017). A non-stationary time series can be made stationary by differentiation; when a distribution achieves stationarity at the first difference it is denoted as $I(1)$, while stationarity achieved at the second difference is denoted by $I(2)$. Statistically,

unit root is often determined by ADF (Dickey and Fuller, 1979) and Phillips-Perron (PP) tests. The ADF test is given as:

$$\Delta X_t = \alpha_0 + \beta \gamma X_{t-1} - \sum_{i=1}^{\rho} \beta_i X_{t-i} + \varepsilon_t \quad (2)$$

where X_t is the stationary series, α_0 is the intercept, ρ is the lag operator, and t is the time, while ε is the error term. Akaike Information Criterion (AIC) is used to determine the lag length of the equation (Hu and Brorsen, 2017).

3.2.2 Cointegration

Cointegration analysis was first introduced by Granger in 1981 and further modified by Engel Granger, as well as Engel and Yoo, in 1987. The Johansen and Juselius (1994) cointegration technique is used in a multivariate analysis that is all integrated in the same order, while ARDL is used for a bivariate analysis integrated of order I(0) (Otieno, 2017). The essence is to determine if a long-run relationship exists between the variables of interest; this information enables the analyst to decide on the use of VAR or an Error Correction Model (ECM)/Vector Error Correction Model (VECM) (Ripplinger et al., 2017; Obayelu and Salau, 2010). Studies (Endera, 2010; Shaik and Miljkovic, 2010; Daly et al., 2017; Mahmood et al., 2017) show that, in the presence of cointegration and stationarity on the order I(1), a VECM or ECM is preferable depending on the stipulated objective.

3.2.3 Vector Autoregressive Model (VAR)

The VAR model is a general framework used to describe the dynamic interrelationship among non-stationary variables. In time-series analysis, the first step is to determine whether the levels of the data are stationary; if not, the first difference of the series is verified. Usually, if the levels or log-levels of the time-series are not stationary, the first difference will be stationary. If the time series are not stationary, then the VAR framework needs to be modified to allow consistent estimation of the relationships among the series.

The VAR is one of the most successful, flexible models for the analysis of multivariate time series. It is a natural extension of the univariate autoregressive model to dynamic multivariate time series. It has proven to be especially useful for describing the dynamic behavior of economic and financial time series and for forecasting. It often provides superior forecasts to those from univariate time series models and elaborate theory-based simultaneous equations models. The VAR model fits this study in the sense that vector estimates of the series are generated and the causal effects are assessed simultaneously.

This study adapts VAR as earlier used by Hamilton (1983) and Bjørnland (1996) to analyze the effect of price shocks to verify the causality between commercial fertilizer price and subsidized fertilizer price. The theoretical methodological framework is represented as follows:

$$\begin{pmatrix} \Delta COMp \\ \Delta SUBp \end{pmatrix} = \begin{pmatrix} b_{11i} & b_{12i} \\ b_{21i} & b_{22i} \end{pmatrix} \begin{pmatrix} \phi_{1t} \\ \phi_{2t} \end{pmatrix} \quad (3)$$

Where $\Delta COMp$, $\Delta SUBp$ represents the first difference of commercial fertilizer prices in time (t), ϕ_{1t} , and ϕ_{2t} are the uncorrelated white noise disturbances and b_{11i} , b_{12i} , b_{21i} , and b_{22i} are polynomials

in the lag operator where the individual coefficients are denoted as b_i . The series in equation (4) can be endogenized in a VAR model system as follows:

$$\Delta COM p_t = \alpha_0 + \sum_{t-1}^n \beta_{11i} \Delta COM p_{t-1} + \sum_{t-1}^n \beta_{12i} \Delta SUB_{t-1} + \varepsilon_t \quad (4)$$

$$\Delta SUB p_t = \alpha_0 + \sum_{t-1}^n \beta_{21i} \Delta SUB p_{t-1} + \sum_{t-1}^n \beta_{22i} \Delta COM p_{t-1} + \varepsilon_t \quad (5)$$

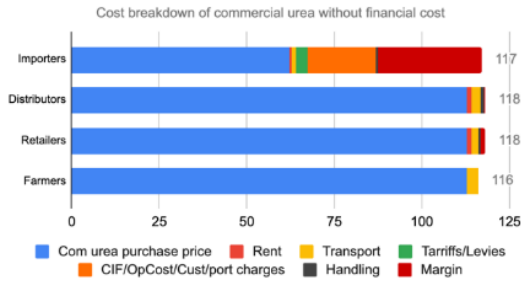
CHAPTER 4: RESULTS

4.1 Cost Components and Distribution of Margins

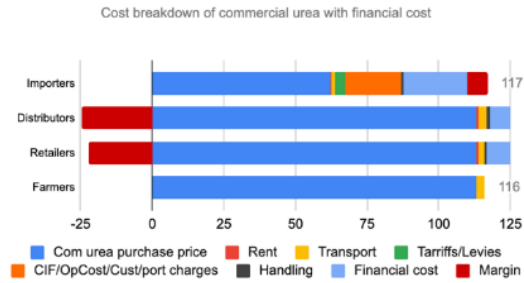
A total of 394 respondents, comprising of 153 agro-dealers (5 importers 42 distributors, 106 retailers) and 241 farmers, were surveyed. Table 3 shows the cost breakdown and margins for value chain actors from point of purchase to point of sale. The results revealed that NPK fertilizer prices were relatively higher than straight fertilizer prices, such as urea and ammonium sulfate (SoA). This price difference is to be expected, as NPK contains more essential nutrients compared to urea and SoA. However, some price inconsistencies were observed within the value chain, as some retail fertilizer prices were lower than the prices offered by distributors (wholesalers); for example, the average price for which retailers purchased commercial NPK 12:22:21 was 98 GHC and sold for 137 GHC, while distributors' (wholesalers') average purchase price for the same fertilizer was 121 GHC and sold for 133 GHC (Appendix Table 1A). In some cases, there was no difference between the retail price and the distribution price; this can be attributed to non-stratification of the downstream fertilizer market, as most distributors also retail fertilizers. Furthermore, the highest cost associated with fertilizers is the purchase price followed by financial cost, transportation cost, and cost of rent. Margins are unevenly distributed and highly skewed toward fertilizer importers, especially when margins are adjusted for financial cost. For example, when financial cost is factored into the total cost of commercial urea, only the importers have positive margins while distributors and retailers make negative margins.

Table 3. Cost and margin breakdown of three fertilizer types per 50-kg bag

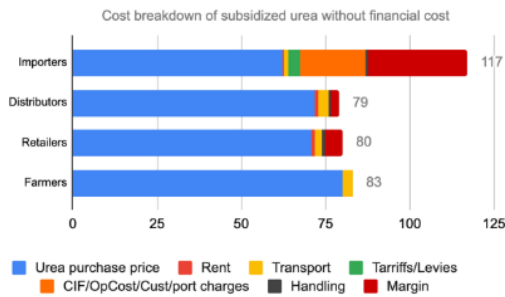
Commercial Urea												
Actor	Urea Purchase Price/50kg	Rent/50kg	Transport/50kg	Tariffs/Levies/50kg	CIF/OpCost/Cust/Port Charges	Handling/50kg	Financial Cost/50kg	Selling	Margin	%Margin with Finance/50kg	% Margin without Finance Cost/50kg	
Importer	62.21	0.58	1.15	3.5	19.33	0.86	22.5	117	6.87	6.24%	33.52%	
Distributor	113	1	2.83	0	0	0.96	24.7	118	-24.49	-17.19%	0.18%	
Retailer	113	1	2	0	0	0.86	23.51	118	-22.36	-15.93%	0.98%	
Farmer	113	0	3									
Subsidized Urea												
Actor	Urea Purchase Price/50kg	Rent/50kg	Transport/50kg	Tariffs/Levies/50kg	CIF/OpCost/Cust/Port Charges	Handling/50kg	Financial Cost/50kg	Selling/50kg	Margin/50kg	%Margin with Finance/50kg	% Margin without Finance Cost/50kg	
Importer	62.21	0.58	1.15	3.5	19.33	0.86	22.5	117	6.87	6.24%	33.52%	
Distributor	72	1	2.83	0	0	0.96	18.9	79	-16.69	-17.44%	2.88%	
Retailer	71	1	2	0	0	0.86	17.66	80	-12.52	-13.53%	6.87%	
Farmer	80	0	3									
Commercial SoA												
Actor	SoA Purchase Price/50kg	Rent/50kg	Transport/50kg	Tariffs/Levies/50kg	CIF/OpCost/Cust/Port Charges/50kg	Handling/50kg	Financial Cost/50kg	Selling/50kg	Margin/50kg	%Margin with Finance/50kg	% Margin without Finance Cost/50kg	
Importer	40.32	0.58	1.15	3.5	19.33	0.86	13.15	85	6.11	7.75%	29.30%	
Distributor	87	1	3	0	0	1	22.65	94	-20.65	-18.01%	2.17%	
Retailer	89	1	2	0	0	1	21.94	100	-14.94	-13.00%	7.53%	



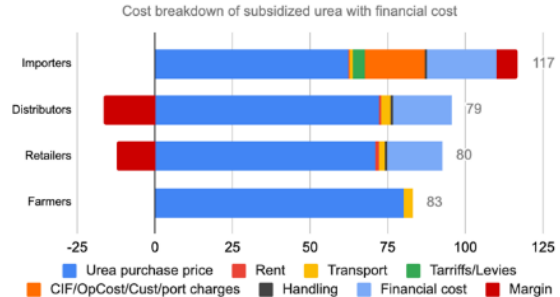
(a)



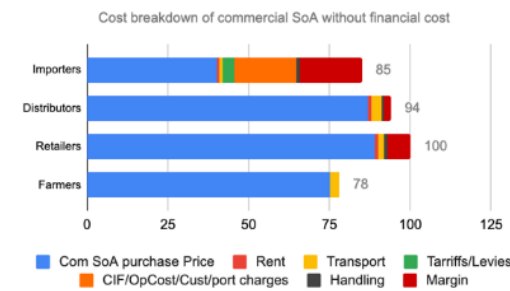
(b)



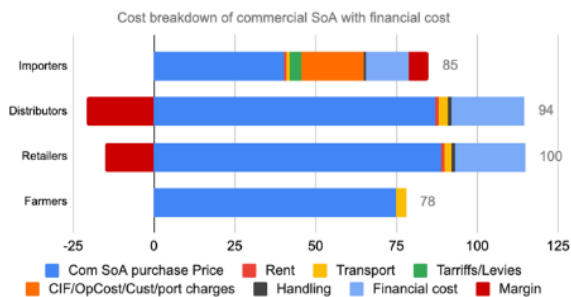
(c)



(d)



(e)



(f)

Figure 7. Cost breakdown and margin distribution along the value chain for a 50-kg bag of commercial urea, subsidized urea, and SoA

Figure 7 shows the distribution of margins and cost breakdown among value chain actors. For commercial urea, importers had a net positive margin (with and without the adjustment of financial cost), while distributors and retailers had low margins without factoring in financial cost. Meanwhile, when financial costs are factored in, distributors and retailers both made negative margins of -17.19% and -15.13%, respectively. This was the case for all three fertilizers investigated in this survey. Therefore, since all stakeholders' margins after factoring in financial costs were below 14.46%, which is the 365-day treasury bill rate in Ghana, we accept our null hypothesis, which states that stakeholder margins for commercial fertilizers are below the Bank of Ghana's 365-day treasury bill rate of 14.46% (BoG, 2020). The uneven distribution of margins is consistent with the observation by Fuentes et al. (2011) and IFDC (2019) that the exclusion of

agro-dealers from subsidy price negotiation erodes their profitability, since they cannot hedge against risk and other macroeconomic fluctuations enjoyed by fertilizer importers. Also, farmers on average experienced a 3.75% increase in the retail price of fertilizers as a result of transportation cost. In addition, Figure 8 reveals that some agro-dealers seemed to be adjusting to market constraint, as 14% of distributors and 19% of retailers collected grains during harvest in exchange for fertilizers.

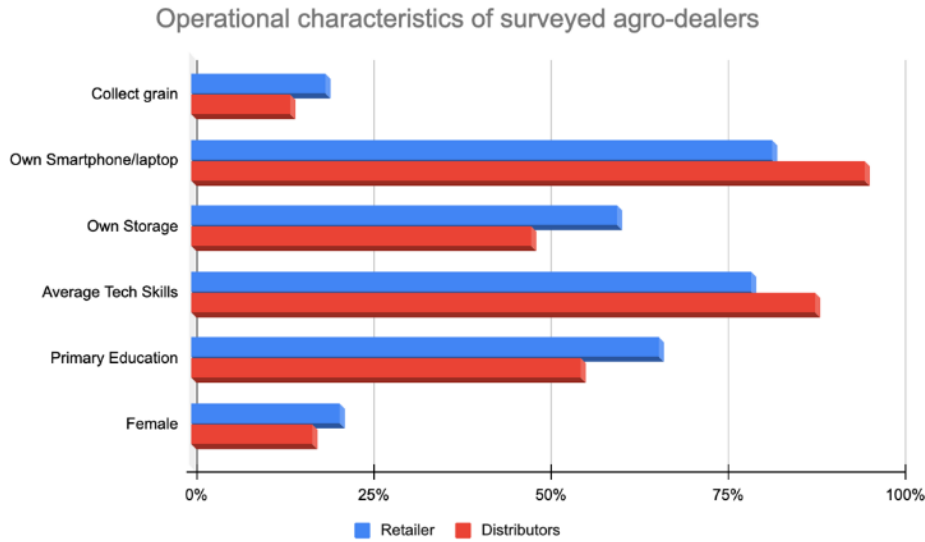


Figure 8. Operational characteristics of surveyed agro-dealers in percentage

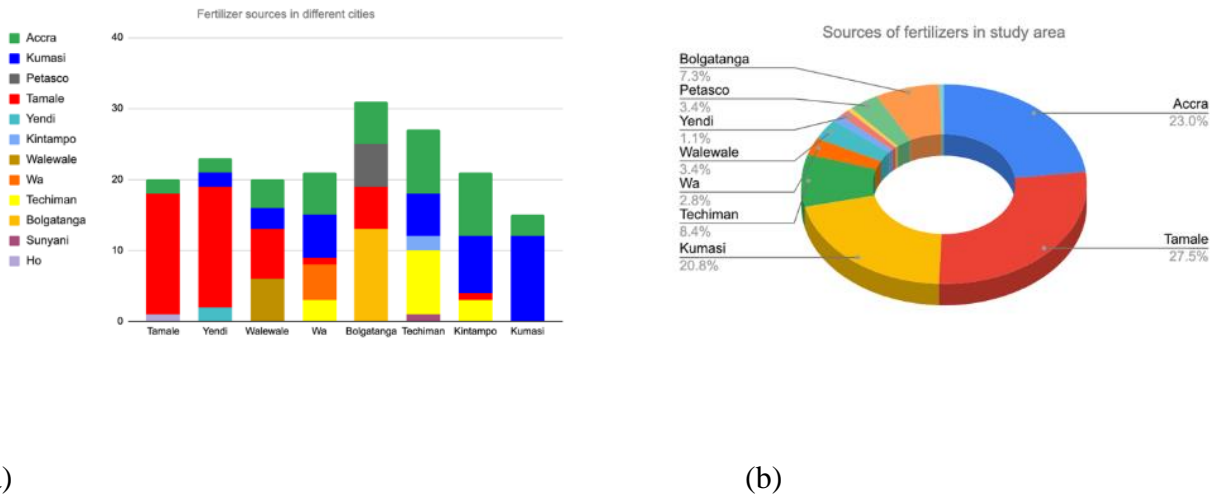


Figure 9. (a) Total fertilizer sources in cities by agro-dealers and (b) percentage share of fertilizer source in study area

Figure 9 (a and b) highlights the sources of fertilizers in individual cities surveyed, with Tamale, Accra, and Kumasi being the major source of fertilizers in the study regions. Accra is the point of entry for most fertilizers due to the port at Tema, while Tamale is a major fertilizer hub in the north

and hosts some fertilizer importers. It was observed that fertilizer retail prices increased with transaction cost, as seen in Ashanti, Bono East, and Northern regions. However, Figure 10 revealed fertilizer retail prices were highest in the Northern region but lowest in the North-East region, which is in line with the observation of Bonilla et al. (2020) that commercial fertilizer prices were lower farther north in Ghana.

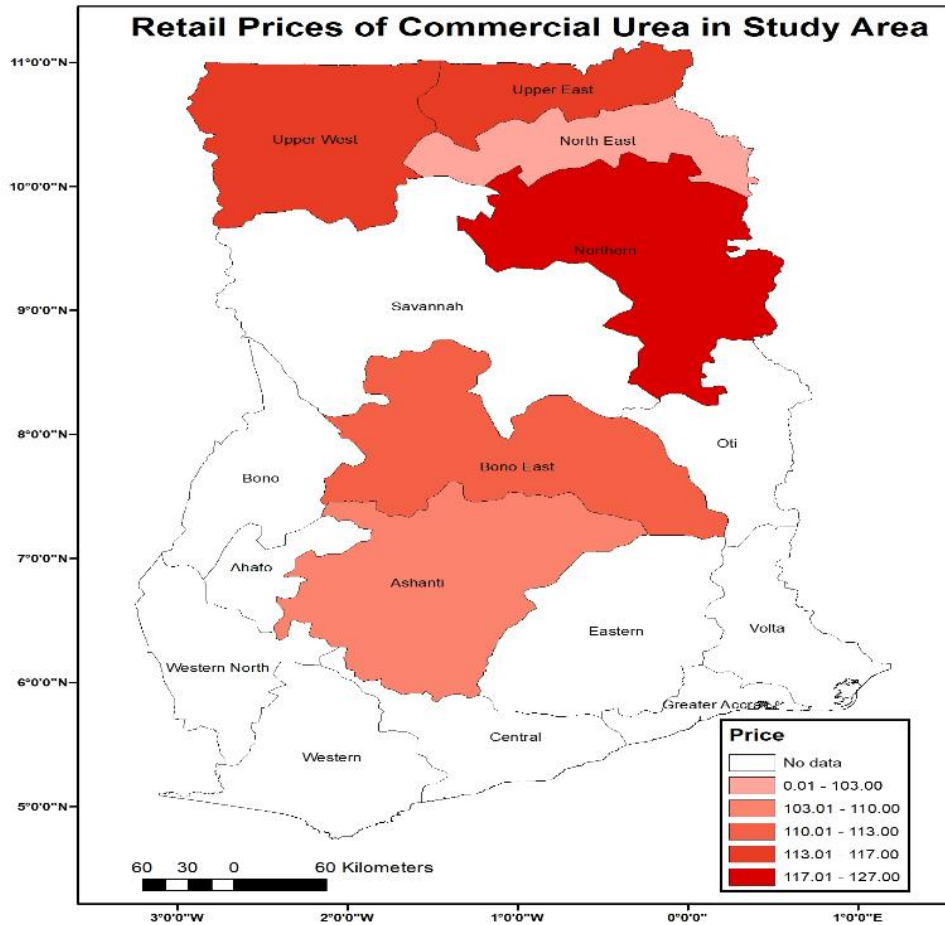


Figure 10. Map presenting fertilizer retail prices within the study areas

4.2 Market Integration

4.2.1 Unit Root Analyses

Market integration was investigated to understand spatial price transmission between Kasoa, Koforidua, Takoradi, Techiman, Mankessim, Seckondi, and Wench markets. Unit root analyses were conducted using the ADF test based on Akaike Info Criterion (AIC). The unit root analyses in Table 4 revealed all markets had unit root at level and were stationary only at first difference. Therefore, they are integrated at I(1).

Table 4. Unit root analyses

Variables	5% C.V.	Level	1st Diff	Order
Seckondi Market	-2.896779	-1.975771	-7.221907	I(1)
Takoradi Market	-2.896346	-2.346104	-7.365407	I(1)
Techiman Market	-2.896346	-2.088279	-7.115513	I(1)
Wench Market	-2.896346	-2.176433	7.340624	I(1)
Kasoa Market	-2.896779	-0.461549	-7.786163	I(1)
Koforidua Market	-2.899115	-1.633092	-3.241306	I(1)
Mankessim Market	-2.899619	-1.53923	-6.081129	I(1)

Note: C.V. means critical value, 1st Diff is first difference, and Order means order of integration.

4.2.2 Market Cointegration

Following the observed non-stationarity of the markets at level, cointegration analyses were carried out to investigate whether the markets have a long-run relationship. The Johansen (1991) cointegration technique was adopted. The trace and maximum eigenvalue test results in Table 5 reveal that there are two cointegrating equations among the markets investigated.

Table 5. Result of trace and eigenvalue cointegration test

No. of CE(s)	Eigenvalue	Trace Stat	5% C.V.	Prob.
None *	0.515405	155.2104	125.6154	0.0002
At most 1 *	0.472945	103.0506	95.75366	0.0143
At most 2	0.319450	56.93817	69.81889	0.3412
At most 3	0.186705	29.22870	47.85613	0.7574
At most 4	0.110963	14.34905	29.79707	0.8204
At most 5	0.058011	5.880675	15.49471	0.7096
At most 6	0.021676	1.577857	3.841466	0.2091

Result of cointegration (maximum eigenvalue)

No. of CE(s)	Eigenvalue	Max-Eigen	5% C.V.	Prob.
None *	0.515405	52.15984	46.23142	0.0104
At most 1 *	0.472945	46.11241	40.07757	0.0093
At most 2	0.319450	27.70947	33.87687	0.2272
At most 3	0.186705	14.87965	27.58434	0.7577
At most 4	0.110963	8.468371	21.13162	0.8728
At most 5	0.058011	4.302818	14.26460	0.8261
At most 6	0.021676	1.577857	3.841466	0.2091

*Note: Trace and maximum eigenvalue tests indicate two cointegrating eqn(s) at the 0.05 level; C.V. means critical value while * denotes rejection of the hypothesis at the 0.05 level.*

Following the result of two cointegrating equations in Table 5, a bivariate analysis was investigated to identify market pairs that are convergent in the long run. A converging market implies that current inefficiencies within the markets can be addressed in the future by policies and restructuring. The results revealed only three market pairs exhibited long-run relationship with each other. The co-integrating markets in Table 6 include: **Seckondi and Takoradi** markets; **Techiman and Takoradi** markets; and **Wench and Takoradi** markets. About 86% of the market pairs failed to show a long-run relationship. Based on results in Table 5 and 6, it can be inferred that, for the markets investigated, Ghana's fertilizer markets are not spatially integrated; therefore, the research null hypothesis is accepted.

Table 6. Bivariate market cointegration results

MARKET	SECK_	TAKO_	TECH_	WENC	KASO	KOFO	MANK_
SECK_		YES	NO	NO	NO	NO	NO
TAKO_	YES		YES	YES	NO	NO	NO
TECH_	NO	YES		NO	NO	NO	NO
WENC_	NO	YES	NO		NO	NO	NO
KASO_	NO	NO	NO	NO		NO	NO
KOFO_	NO	NO	NO	NO	NO		NO
MANK_	NO	NO	NO	NO	NO	NO	

4.3 Relationship Between Commercial and Subsidized Fertilizers

4.3.1 Unit Root

In order to investigate the price relationship between commercial and subsidized fertilizers, a unit root analysis was conducted through an ADF test based on AIC to observe whether the variables are mean reverting and can be utilized for statistical analyses at level. The subsidized fertilizers

investigated include subsidized urea (SUREA), subsidized NPK 15:15:15 (SNPK), commercial urea (CUREA), and commercial NPK 15:15:15 (CNPK). The ADF test revealed the presence of unit root at level for all variables; however, the variables became stationary at first difference. Table 7 revealed all the variables are integrated on the order of I(1). The unit root analysis verified the convergent capacity of the prices in the long run. Therefore, the properties of the data series of all the variables indicate that this study can proceed to carrying out a cointegration test between the variables in order I(1), using the Johansen (1991) techniques.

Table 7. Subsidized and commercial fertilizers Unit root analyses

Variables	5% C.V.	Level	1 st Diff.	Order
CNPK	-2.90621	-1.556696	4.503577	I(1)
SNPK	-2.921175	0.930954	-6.238303	I(1)
CUREA	-2.903566	-1.049207	-8.547421	I(1)
SUREA	-2.919952	0.818019	-6.382652	I(1)

Note: C.V. means critical value; 1st Diff. means first difference, and Order means the order of integration.

4.3.2 Subsidized and Commercial Fertilizers Price Cointegration Analysis (2012-2019)

In conducting a cointegration test between the variables with the aim of estimating the relationship between the prices of the different types of fertilizers in Ghana, this study adopted the Johansen (1991) method, which is less restrictive to cointegration. The results of the cointegration test are shown in Table 8. In this test, the null hypothesis, which stipulates that there is no relationship between the variables, is accepted because the coefficients of trace and maximum eigenvalue of 36.32 and 20.78, respectively, are less than their corresponding critical values. Also, their *p*-values are higher than the 5% level of significance. Specifically, the results by trace and maximum eigenvalue tests found no cointegrating equations. The results imply that there is no long-run relationship between the variables; in essence, there is no long-run relationship between the prices of the different types of fertilizers (SUREA, SNPK, CUREA, and CNPK) investigated in this study in Ghana. In view of this, it is imperative to conduct a short-run analysis to examine whether a short-run relationship exists between these variables through a VAR analysis.

Table 8. Unrestricted cointegration rank test

Trace eigenvalue

No. of CE(s)	Eigenvalue	Trace	5% C.V.	Prob.**
None	0.511619	36.32105	47.85613	0.3804
At most 1	0.335510	15.53794	29.79707	0.7443
At most 2	0.109776	3.684591	15.49471	0.9273
At most 3	0.010715	0.312412	3.841466	0.5762

Maximum eigenvalue

No. of CE(s)	Eigenvalue	Max-Eigen	5% C.V.	Prob.**
None	0.511619	20.78311	27.58434	0.2896
At most 1	0.335510	11.85335	21.13162	0.5622
At most 2	0.109776	3.372180	14.26460	0.9189
At most 3	0.010715	0.312412	3.841466	0.5762

*Note: Trace and maximum eigenvalue tests indicates no cointegrating eqn(s) at the 0.05 level; C.V. means critical value, while * denotes rejection of the hypothesis at the 0.05 level.*

4.4 Vector Auto Regressive Model for Subsidized and Commercial Fertilizer Monthly Prices (2012-2019)

The VAR model begins with the VAR Lag Order Selection. The results of the Likelihood Ratio (LR), sequential modified LR test statistic, final prediction error (FPE), AIC, Schwarz information criterion (SC); and Hannan-Quinn information criterion (HQ) all supported a lag length of 2 for the variables. Consequently, the VAR model was estimated based on lag 2, and the results are presented in Table 9.

Table 9. VAR result on commercial NPK and subsidized NPK

	CNPK	SNPK
CNPK(-1)	0.496028 (0.15358) [3.22978]	-0.036943 (0.05980) [-0.61778]
CNPK(-2)	0.337847 (0.15379) [2.19684]	-0.041173 (0.05988) [-0.68757]
SNPK(-1)	1.035798 (0.42843) [2.41766]	0.928045 (0.16682) [5.56312]
SNPK(-2)	-0.976656	0.121003

	CNPK	SNPK
	(0.44772)	(0.17433)
	[-2.18139]	[0.69409]
C	55.66948	19.96889
	(37.1883)	(14.4802)
	[1.49696]	[1.37904]
R-squared	0.795973	0.986912
Adj. R-squared	0.774496	0.985534
Sum sq. residuals	36166.80	5483.397
S.E. equation	30.85058	12.01249
F-statistic	37.06242	716.3421
Log likelihood	-205.8103	-165.2524
Akaike AIC	9.805132	7.918715
Schwarz SC	10.00992	8.123506
Mean dependent	495.4419	392.6512
S.D. dependent	64.96604	99.87561

Table 9 shows a VAR estimate with two models. The R-squared coefficients of 0.80 and 0.99 for CNPK and SNPK, respectively, indicate that the independent variables of the models explain the up to 80% and 99% variations in the dependent variables of the respective models. In the CNPK model, the coefficients of lagged CNPK and SNPK are statistically insignificant. This means that there is no relationship between the lagged CNPK prices and SNPK prices on CNPK prices. In the same vein, the coefficients of lagged CNPK and two-year lagged CNPK are not statistically significant in the SNPK model. To understand the causality, however, the bounds or Wald's test was performed on individual variables in the models. The bounds test output is documented in Appendix 3J.

4.4.1 Model 1: Causality from Subsidized NPK to Commercial NPK

For subsidized NPK, the VAR estimates show a positive relationship with commercial fertilizer in the first period but a negative one in the second period. However, the joint test by the Wald statistics indicates that the lag variable of subsidized NPK fertilizer prices jointly does cause the price of the commercial NPK fertilizer prices. The F-statistic is 4.71. When compared to the upper bound Pesaran table (4.85), it does refute the null hypothesis of no causality. This implies that lags of subsidized NPK cause commercial NPK, which means the price of subsidized NPK influences future prices of commercial NPK.

4.4.2 Model 2: Causality from Commercial NPK to Subsidized NPK

For the commercial NPK price, the VAR estimates showed a negative relationship with commercial NPK fertilizer price in both first and second periods. However, the joint test by the Wald statistics indicates that the lag variable of commercial NPK fertilizer prices jointly does not significantly cause the current price of the subsidized NPK fertilizer. The F-statistic is 2.44, and when compared to the upper bound Pesaran table (4.85), it does confirm the null hypothesis of no

causality. This implies that lags of commercial NPK fertilizer price does not cause current subsidized NPK fertilizer price.

4.4.3 Commercial Urea Prices and Subsidized Urea Prices

The VAR model begins with the VAR Lag Order Selection. The result of LR, sequential modified LR test statistic, FPE, AIC, SC, and HQ all supported a lag length of 2 for the variables in Appendix Table 3B. Consequently, the VAR model was estimated based on lag 2. The results of the VAR analyses between CUREA and SUREA are presented in Table 10.

Table 10. VAR result on commercial and subsidized urea fertilizer

	CUREA	SUREA
CUREA(-1)	0.842581 (0.14514) [5.80537]	-0.025104 (0.04489) [-0.55928]
CUREA(-2)	0.103051 (0.14926) [0.69041]	-0.022035 (0.04616) [-0.47735]
SUREA(-1)	1.872830 (0.51432) [3.64139]	0.944375 (0.15906) [5.93723]
SUREA(-2)	-1.827219 (0.53850) [-3.39315]	0.097235 (0.16654) [0.58385]
C	10.40678 (35.3121) [0.29471]	7.863733 (10.9208) [0.72007]
R-squared	0.846167	0.987822
Adj. R-squared	0.830390	0.986573
Sum sq. resids	63417.84	6065.554
S.E. equation	40.32491	12.47105
F-statistic	53.63056	790.8832
Log likelihood	-222.4461	-170.8095
Akaike AIC	10.33846	7.991341
Schwarz SC	10.54121	8.194090
Mean dependent	485.3636	370.8864
S.D. dependent	97.91455	107.6256

Table 10 shows VAR estimates with two models. The adjusted R-square results show that the models explained 84% and 98% of variations in commercial and subsidized urea prices, respectively, over the time periods considered in this study. The model infers causality between

commercial and subsidized urea fertilizer prices. The inclusion of lags causes insignificant variables; interpreting the output may offer no economic sense. To understand the joint causality effect of these variables, the bounds or Wald test was performed and the results are presented in Appendix 3K.

4.4.4 Model 1: Causality from Subsidized Urea to Commercial Urea

The VAR estimates for SUREA showed a positive relationship with commercial urea fertilizer in the first period but negatively varied in the second lag. However, the joint test by the Wald statistics indicate that the lag variable of subsidized urea fertilizer prices jointly does cause the price of the commercial urea fertilizer. The F-statistic is 8.75. When compared to the upper bound Pesaran table (4.85), it does refute the null hypothesis of no causality. This implies that lags of subsidized urea prices cause commercial urea prices. Hence, it is confirmed that the prevailing price of subsidized urea influences the future price of commercial urea fertilizers. Since the subsidy price is lower than the commercial market fertilizer price, commercial agro-dealers tend to reduce their prices in order to remain competitive. This can be further substantiated by the distribution of margins in Figure 7, which indicates commercial urea had the lowest margins when compared to subsidized urea. Hence, the PFJ FSP's externality effect is likely to be eroding the profitability of commercial fertilizers in Ghana.

4.4.5 Model 2: Causality from Commercial Urea to Subsidized Urea

For the commercial urea price, the VAR estimates showed a negative relationship with the commercial urea fertilizer price in both first and second lags. However, the joint test (Wald test result) indicates that the lag variable of commercial urea fertilizer prices jointly does not cause the price of the subsidized urea fertilizer. The F-statistic is 1.316; when compared to the upper bound Pesaran table (4.85), it confirms the null hypothesis of no causality. This implies that lags of commercial urea fertilizer price do not cause the price of subsidized urea fertilizer. Hence, the research's null hypothesis of commercial fertilizer price causing subsidized fertilizer price is rejected.

CHAPTER 5: DISCUSSION

5.1 Discussion

Findings reveal that Ghana's fertilizer value chain is inefficient, as fertilizer prices are lower in the North-East, Upper-West, and Upper-East regions compared to fertilizer retail prices in the Northern region, which is a major hub for fertilizer trade; most importers interviewed have warehouses in Tamale, the capital of Northern region. While looking at the value chain vertically, prices between distributors and retailers are not consistent, as some fertilizers had higher prices in distribution outlets (wholesale) when compared to retail outlets. Second, price transmissions between fertilizer markets are weak, since only three market pairs were observed to exhibit a long-run relationship. This weak fertilizer market could be a result of asymmetric information, trade barriers, externality effects, or a lack of competition, as stipulated by Dowding and Taylor (2020). However, it cannot be concluded that the observed inefficiency is caused by the FSP, even with the analyses confirming that the price of subsidized fertilizers for both NPK and urea influences the price of subsequent commercial NPK and urea prices, respectively. Further research on fertilizer price transmission is needed on a broader scale, especially for SoA which is not captured under the FSP, to better understand the effect of the FSP on the fertilizer market.

Furthermore, there is optimism in the value chain as the FSP program, through its fertilizer quota, has transformed some distributors to importers as observed in Tamale, which could be why the city is a major fertilizer trading hub.

Also observed was that 14% of distributors and 19% of retailers surveyed collected grains, ranging from soybean, rice, and maize, in place of cash from farmers. Since access to markets and credit are constraints faced by farmers, the exchange of farm commodities for fertilizers seems to be a good alternative for both farmers and fertilizer retailers. Thus, fertilizers are given as credit to be repaid with grains after harvest, which is likely to yield more value with time for these retailers. This provides a lot of opportunities for private sector investment and even for the GoG as a way of providing market-based solutions for farmers and to increase fertilizer consumption. However, more research is needed in the area to establish whether grains for fertilizers induces fertilizer consumption between farmers and whether the farmers get a fair price for their commodities.

It was also observed that 95% of distributors and 82% of retailers own a smartphone or a laptop; 88% of distributors and 79% of retailers rate their skills in using these gadgets above average. This finding encourages the use of ICT in coordinating the fertilizer value chain for smart subsidy programs with more efficiency, which would increase the timeliness along the chain and the quality of information accessed by these agro-dealers (AGRA, 2019).

Finally, gender participation in the value chain is relatively skewed against women and worsens up the chain, as only 21% of retailers and 17% of distributors are women. The low female participation could be a result of gender-based impediments associated with starting a business, such as poor access to finance, low level of education, and cultural disenfranchisement (Aristei and Gallo, 2016; Sauer and Wiesemeyer, 2018; Morsy, 2020).

5.2 Conclusion and Recommendation

In summary, the FSP has successfully increased competition in the fertilizer value chain upstream through its subsidy quota and by making sure importers get appropriate return on investment (ROI) through subsidy negotiations. However, the fertilizer value chain downstream is stifled by low margins that have disincentivized the expansion of distribution and retail networks to remote regions. The effect of a poor distribution network, as highlighted in Figure 7, implies that farmers have the highest average transportation cost per 50-kg bag (GHC 3) in the entire value chain. This could discourage fertilizer use among farmers and further jeopardize the effort of the entire subsidy program. However daunting, these challenges are not insurmountable as the GoG, through MoFA, has continually improved the FSP for greater impact. Examples include the introduction of a new fertilizer formulation for higher productivity and the introduction of designated retailers in border towns to curb fertilizer smuggling to neighboring countries. In light of the challenges outlined, the following are recommended for optimal performance of the fertilizer value-chain.

5.2.1 Inclusive Subsidy Negotiation

An inclusive subsidy negotiation in line with the IFDC optimization study (2019) in which the challenges and cost components of value chain actors until the last mile will guarantee all costs encountered until the fertilizers are delivered to targeted farmers are captured in subsequent negotiations, as depicted in Figure 11. Inclusiveness would also ensure appropriate ROI and galvanize private sector involvement. This can be achieved through a multi-stakeholder platform backed by MoFA and supported by civil society organizations (CSOs), such as the International Fertilizer Development Center (IFDC) and African Fertilizer and Agribusiness Partnership (AFAP). The role of the public sector in the multi-stakeholder platform cannot be overemphasized, as it is the responsibility of the government to provide a conducive environment for the private sector to thrive. However, the role of fertilizers in crop productivity, rural development, and food security makes the platform a top priority for the GoG. An elaborate fertilizer distribution network would reduce farmers' travel time and cost associated with the purchase of fertilizers and induce fertilizer consumption in remote communities.

5.2.2 Cost-Benefit Analyses of the Subsidy Program

The GoG should conduct a cost-benefit analyses of its FSP in order to channel resources into alternative investments with high ROI and social impacts. Alternative subsidy options might provide an exit plan for subsidy interventions.

5.2.3 Subsidized Credit Mechanism

An in-country financial mechanism in line with the *Abuja Declaration* Resolution 7 should be introduced (FAO 2015). A national fertilizer financing mechanism would ensure value chain actors have access to low-interest loans when needed. These would unlock opportunities of economies of scale and lead to upward mobilization, as seen in Tamale where distributors transformed to importers.

5.2.4 Stimulate Private Sector Agtech Companies

Start-up agricultural technology (agtech) companies in SSA, such as Farmcrowdy and Thrive Agric in Nigeria and One Acre Fund in East Africa, are known to provide micro-credit in the form

of inputs for farmers in exchange for money or commodities after harvest. In Nigeria, Farmcrowdy has increased the income of enrolled farmers enrolled by 80% (Farmcrowdy, 2020). In Ghana, agro-dealers are adjusting to market constraints, such as farmers' poor access to finance and commodity markets. These agro-dealers already collect farm commodities in place of cash for fertilizers. However, this provides an opportunity for private sector participation in providing inputs in exchange for farm commodities. This would not only solve the input challenge of farmers but would also address the poor commodity market challenges faced by farmers. The GoG, through policies and financial interventions, can stimulate private sector agtech companies to fill in the gap and reduce the subsidy burden.

5.2.5 Increase Research and Development (R&D)

Agricultural R&D has proven to be integral in agricultural transformation (FAO, 2009). The GoG would need reliable evidence-based research to guide policymaking and implementation in order to fast-track agricultural transformation in Ghana (Shakhovskoy et al., 2020). Due to the profiteering nature of the private sector and the small size of Ghana's fertilizer market, the GoG would have to take the lead in R&D in order to adequately disseminate findings for higher impact.

5.3 Research Perspective

It is possible that some agro-dealers did not provide accurate prices. However, based on the law of large numbers, the more a sample increases, the closer the sample mean moves to the real mean. Hence, our average fertilizer prices, as collated in this survey, are in line with the average fertilizer prices across Ghana, as reported by AfricaFertilizer.org. Furthermore, the VAR model utilized in this study is apt in respect to the non-cointegrating data sets. The price transmission in Ghana fertilizer markets might be different in other market clusters, such as the North of Ghana, but due to data constraints, markets located in the north and east of Ghana were not investigated. For future research, more comprehensive market integration analyses across all fertilizer markets in the 16 regions are recommended. Second, it is germane to ascertain whether the high cost of transportation paid by farmers acts as a disincentive to the use of fertilizers by farmers. Finally, we established that subsidized fertilizer prices influence the subsequent prices of commercial fertilizers; however, we could not establish whether subsidized fertilizers were crowding out commercial fertilizers at the retail outlets since commercial fertilizer prices had the lowest margins for all value chain actors.

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Appendices

Appendix 1. Objective 1: Cost Components and Distribution of Margins

Appendix Table 1A. Descriptive statistics

Retailers																																			
NPK 12 22 21				NPK 12 30 17				NPK 20 10 10				NPK 23 10 5				NPK 25 10 10				NPK15 20 20				Urea				Ammonium Sulfate							
Commercial		Subsidized		Commercial		Subsidized		Commercial		Subsidized		Commercial		Subsidized		Commercial		Subsidized		Commercial		Subsidized		Commercial		Subsidized		Commercial							
Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Hand cost	Inte rate	Fin Cost (Urea)	Trans/bag	Rent/bag	
Mean	98	137	74	80	114	141	73	83	116	121	74	80	114	127	73	79	111	124	73	80	113	119	73	77	113	118	71	80	89	100	1	0	24	2	1
Median	98	130	74	80	115	135	75	84	115	120	70	75	115	120	72	75	115	120	70	78	110	120	70	75	112	120	70	80	90	100	1	0	24	2	1
Maximum	100	168	76	90	130	168	75	90	168	168	95	100	168	168	85	90	168	168	90	95	168	168	84	84	160	160	86	90	120	130	5	0	38	8	3
Minimum	95	110	70	74	95	120	70	75	90	90	65	74	86	110	50	70	75	90	60	70	95	84	69	71	90	90	60	65	68	68	0	0	6	0	1
Std. Dev	3.5	25.1	2.3	5.6	14.9	24.6	2.5	7.5	16.1	15.0	6.5	7.9	16.5	16.5	6.2	4.9	15.7	17.6	5.5	5.5	14.6	17.7	4.4	4.2	19.1	18.1	5.6	4.2	11.2	17.2	0.7	0.0	6.5	1.5	0.4
Skewness	0.0	0.4	-0.7	0.5	-0.2	0.4	-0.6	-0.2	1.2	1.6	1.7	1.6	1.3	1.7	-0.8	0.4	0.9	1.3	0.8	0.5	2.5	1.5	1.3	0.9	1.0	0.7	0.3	-0.6	0.2	0.0	3.0	-3.3	-0.2	1.1	2.6
Kurtosis	1.0	1.5	2.3	2.1	1.7	1.5	1.5	1.5	5.5	7.3	5.6	4.3	5.5	4.8	5.1	2.0	6.8	4.7	4.6	2.4	10.4	6.2	3.6	2.1	3.6	3.3	2.3	5.5	2.7	1.8	17.2	20.0	3.9	4.2	9.1
Jarque-Bera	0.3	0.7	0.5	0.6	0.3	0.4	1.0	0.3	14.7	36.9	21.2	16.6	21.6	21.2	18.3	3.6	25.4	19.4	8.7	2.6	73.1	17.9	9.2	4.0	8.6	4.0	2.7	21.3	0.6	3.2	976.2	1183.0	1.9	28.0	110.2
Probability	0.8	0.7	0.8	0.7	0.9	0.8	0.6	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.1	0.0	0.1	0.3	0.0	0.7	0.2	0.0	0.0	0.4	0.0	0.0

Distributors																																			
NPK 12 22 21				NPK 12 30 17				NPK 20 10 10				NPK 23 10 5				NPK 25 10 10				NPK15 20 20				Urea				Ammonium Sulfate							
Commercial		Subsidized		Commercial		Subsidized		Commercial		Subsidized		Commercial		Subsidized		Commercial		Subsidized		Commercial		Subsidized		Commercial		Subsidized		Commercial							
	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell	Hand cost	Inte rate	Fin Cost (Urea)	Trans/bag	Rent/bag
Mean	121	133	78	80	124	120	78	80	123	128	78	83	118	130	74	82	116	126	74	81	120	125	76	81	113	118	72	79	87	94	1	0	25	3	1
Median	110	120	77	84	110	120	75	82	113	120	81	84	120	130	74	84	113	128	74	84	110	120	75	84	110	120	72	80	85	90	1	0	24	3	1
Maximum	168	168	84	84	168	120	84	84	168	168	84	84	168	168	84	90	168	168	84	90	168	168	84	84	160	160	80	85	145	120	5	1	40	8	3
Minimum	80	90	69	70	95	120	70	70	95	90	66	75	95	90	64	72	72	60	66	60	95	90	66	71	90	80	63	68	50	60	0	0	8	0	1
Std. Dev	32.3	34.0	6.0	5.6	31.6	NA	6.1	6.6	27.9	30.0	6.5	2.6	20.9	21.2	6.7	4.7	26.2	25.8	5.9	6.1	27.0	26.2	6.6	4.8	19.6	16.5	5.4	4.1	19.5	14.9	1.0	0.1	8.8	2.2	0.6
Skewness	0.5	0.0	-0.1	-1.0	0.5	NA	0.0	-0.9	0.8	0.3	-0.5	-2.6	1.1	0.1	0.2	-0.7	0.7	-0.9	0.6	-0.2	1.0	0.6	0.0	-1.0	1.0	0.0	-0.1	-1.4	1.1	0.0	3.0	4.1	-0.1	0.8	2.2
Kurtosis	1.8	1.5	1.5	2.4	1.6	NA	1.3	2.1	2.1	1.7	1.8	8.4	3.6	2.7	1.7	2.4	2.9	4.0	2.2	6.2	2.3	2.3	1.7	2.5	3.5	4.0	1.8	4.7	4.5	2.6	12.0	23.8	2.1	2.7	6.5
Jarque-Bera	0.9	0.5	0.8	1.2	0.6	NA	0.9	0.7	1.4	0.5	1.6	33.0	4.6	0.1	2.1	2.3	1.3	1.5	1.9	24.8	1.9	0.6	1.0	2.0	4.6	0.9	1.7	12.2	7.9	0.2	199.1	870.4	0.9	4.3	15.9
Probability	0.6	0.8	0.7	0.5	0.7	NA	0.7	0.7	0.5	0.8	0.5	0.0	0.1	1.0	0.4	0.3	0.5	0.5	0.4	0.0	0.4	0.7	0.6	0.4	0.1	0.6	0.4	0.0	0.0	0.9	0.0	0.0	0.6	0.1	0.0

Appendix Table 1B. Percentage composition of stakeholders in survey area

Attributes	Retailer %	Distributor %
Gender		
Female	21	17
Male	79	83
Education		
None	34	45
Primary school	44	40
Junior high	6	5
High school	3	2
Tertiary	14	7
Smartphone Ownership		
Do not own	18	5
Own	82	95
Technology Skill		
Very bad	13	7
Bad	8	5
Average	25	21
Good	25	31
Very good	28	36
Storage Ownership		
No	40	52
Yes	60	48
Mode of Payment		
Collect grain	19	14
Cash only	81	86

Appendix 2A. Determine the Level of Market Integration in the Fertilizer Value Chain

UNIT ROOT TEST- KASOA MARKET AT LEVEL

Null Hypothesis: KAS_MAK has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-0.461549	0.8924
Test critical values: 1% level	-3.511262	
5% level	-2.896779	
10% level	-2.585626	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST- KASOA MARKET AT FIRST DIFFERENCE

Null Hypothesis: D(KAS_MAK) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-7.786163	0.0000
Test critical values: 1% level	-3.513344	
5% level	-2.897678	
10% level	-2.586103	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST- KOFORIDUA MARKET AT LEVEL

Null Hypothesis: KOF_MAK has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.633092	0.4610
Test critical values: 1% level	-3.516676	
5% level	-2.899115	
10% level	-2.586866	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST- KOFORIDUA MARKET AT FIRST DIFFERENCE

Null Hypothesis: D(KOF_MAK) has a unit root

Exogenous: Constant

Lag Length: 2 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.241306	0.0214
Test critical values: 1% level	-3.520307	
5% level	-2.900670	
10% level	-2.587691	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST - MANKESSIM MARKET AT LEVEL

Null Hypothesis: MAN_MAK has a unit root

Exogenous: Constant

Lag Length: 2 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.539230	0.5086
Test critical values: 1% level	-3.517847	
5% level	-2.899619	
10% level	-2.587134	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST - MANKESSIM MARKET AT FIRST DIFFERENCE

Null Hypothesis: D(MAN_MAK) has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-6.081129	0.0000
Test critical values: 1% level	-3.517847	
5% level	-2.899619	
10% level	-2.587134	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST- SECKONDI MARKET AT LEVELS

Null Hypothesis: SEK_MAR has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.975771	0.2969
Test critical values: 1% level	-3.511262	
5% level	-2.896779	
10% level	-2.585626	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST- SEKONDI MARKET AT FIRST DIFFERENCE

Null Hypothesis: D(SEK_MAR) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-7.221907	0.0000
Test critical values: 1% level	-3.511262	
5% level	-2.896779	
10% level	-2.585626	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST- TAKORADI MARKET AT LEVEL

Null Hypothesis: TAK_MAK has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.346104	0.1603
Test critical values: 1% level	-3.510259	
5% level	-2.896346	
10% level	-2.585396	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST- TAKORADI MARKET AT FIRST DIFFERENCE

Null Hypothesis: D(TAK_MAK) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-7.365407	0.0000
Test critical values: 1% level	-3.510259	
5% level	-2.896346	
10% level	-2.585396	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST- TECHNIMAN MARKET AT LEVELS

Null Hypothesis: TECH_MAK has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.088279	0.2499
Test critical values: 1% level	-3.510259	
5% level	-2.896346	
10% level	-2.585396	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST- TECHNIMAN MARKET AT FIRST DIFFERENCE

Null Hypothesis: D(TECH_MAK) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-7.115513	0.0000
Test critical values: 1% level	-3.510259	
5% level	-2.896346	
10% level	-2.585396	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST- WENCH MARKET AT LEVEL

Null Hypothesis: WEN_MAK has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.176433	0.2164
Test critical values: 1% level	-3.510259	
5% level	-2.896346	
10% level	-2.585396	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST- WENCH MARKET AT FIRST DIFFERENCE

Null Hypothesis: D(WEN_MAK) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-7.340624	0.0000
Test critical values: 1% level	-3.510259	
5% level	-2.896346	
10% level	-2.585396	

*MacKinnon (1996) one-sided p-values.

Appendix 2B. Market Cointegration (Long-Run Relationship)

Date: 06/05/20 Time: 19:21

Sample (adjusted): 5 80

Included observations: 72 after adjustments

Trend assumption: Linear deterministic trend

Series: KAS_MAK KOF_MAK MAN_MAK SEK_MAR TAK_MAK

TECH_MAK WEN_MAK

Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.515405	155.2104	125.6154	0.0002
At most 1 *	0.472945	103.0506	95.75366	0.0143
At most 2	0.319450	56.93817	69.81889	0.3412
At most 3	0.186705	29.22870	47.85613	0.7574
At most 4	0.110963	14.34905	29.79707	0.8204
At most 5	0.058011	5.880675	15.49471	0.7096
At most 6	0.021676	1.577857	3.841466	0.2091

Trace 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

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.515405	52.15984	46.23142	0.0104
At most 1 *	0.472945	46.11241	40.07757	0.0093
At most 2	0.319450	27.70947	33.87687	0.2272
At most 3	0.186705	14.87965	27.58434	0.7577
At most 4	0.110963	8.468371	21.13162	0.8728
At most 5	0.058011	4.302818	14.26460	0.8261
At most 6	0.021676	1.577857	3.841466	0.2091

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

Appendix 3. Relationship between Commercial and Subsidized Fertilizers

Appendix 3A

UNIT ROOT TEST NPK AT LEVELS

Null Hypothesis: NPK has a unit root

Exogenous: Constant

Lag Length: 2 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.556696	0.4989
Test critical values: 1% level	-3.533204	
5% level	-2.906210	
10% level	-2.590628	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST NPK AT FIRST DIFFERENCE

Null Hypothesis: D(NPK) has a unit root

Exogenous: Constant

Lag Length: 2 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-4.503577	0.0005
Test critical values: 1% level	-3.538362	
5% level	-2.908420	
10% level	-2.591799	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST- SUBSIDIZED NPK AT LEVEL

Null Hypothesis: SNPK has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	0.930954	0.9952
Test critical values: 1% level	-3.568308	
5% level	-2.921175	
10% level	-2.598551	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST- SUBSIDIZED NPK AT FIRST DIFFERENCE

Null Hypothesis: D(SNPK) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-6.238303	0.0000
Test critical values: 1% level	-3.592462	
5% level	-2.931404	
10% level	-2.603944	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST SUBSIDIZED UREA AT LEVEL

Null Hypothesis: SUREA has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	0.818019	0.9934
Test critical values: 1% level	-3.565430	
5% level	-2.919952	
10% level	-2.597905	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST SUBSIDIZED UREA AT FIRST DIFFERENCE

Null Hypothesis: D(SUREA) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-6.382652	0.0000
Test critical values: 1% level	-3.588509	
5% level	-2.929734	
10% level	-2.603064	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST UREA AT LEVEL

Null Hypothesis: UREA has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.049207	0.7315
Test critical values: 1% level	-3.521579	
5% level	-2.901217	
10% level	-2.587981	

*MacKinnon (1996) one-sided p-values.

UNIT ROOT TEST UREA AT FIRST DIFFERENCE

Null Hypothesis: D(UREA) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on AIC, maxlag=2)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-8.547421	0.0000
Test critical values: 1% level	-3.527045	
5% level	-2.903566	
10% level	-2.589227	

*MacKinnon (1996) one-sided p-values.

Appendix 3B

LAG SELECTION FOR COINTEGRATION

A)VAR Lag Order Selection Criteria

Endogenous variables: NPK SNPK UREA SUREA

Exogenous variables: C

Date: 06/05/20 Time: 20:22

Sample: 1 97

Included observations: 36

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-728.8986	NA	5.66e+12	40.71659	40.89254	40.77800
1	-549.6333	308.7347	6.56e+08	31.64629	32.52603	31.95334
2	-532.1014	26.29782	6.25e+08	31.56119	33.14471	32.11388
3	-490.9673	52.56027*	1.70e+08*	30.16485*	32.45215*	30.96318*

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Appendix 3C

COINTEGRATION TEST- NPK SNPK SUREA UREA

Date: 06/05/20 Time: 20:23
Sample (adjusted): 5 94
Included observations: 29 after adjustments
Trend assumption: Linear deterministic trend
Series: NPK SNPK SUREA UREA
Lags interval (in first differences): 1 to 3

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.511619	36.32105	47.85613	0.3804
At most 1	0.335510	15.53794	29.79707	0.7443
At most 2	0.109776	3.684591	15.49471	0.9273
At most 3	0.010715	0.312412	3.841466	0.5762

Trace test indicates no cointegration at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.511619	20.78311	27.58434	0.2896
At most 1	0.335510	11.85335	21.13162	0.5622
At most 2	0.109776	3.372180	14.26460	0.9189
At most 3	0.010715	0.312412	3.841466	0.5762

Max-eigenvalue test indicates no cointegration at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Appendix 3D

RESULT OF VAR MODELLING FOR *SUBSIDIZED AND COMMERCIAL FERT.*

Vector Autoregression Estimates

Date: 06/05/20 Time: 20:37

Sample (adjusted): 3 94

Included observations: 43 after adjustments

Standard errors in () & t-statistics in []

	NPK	SNPK
CNPK(-1)	0.496028 (0.15358) [3.22978]	-0.036943 (0.05980) [-0.61778]
CNPK(-2)	0.337847 (0.15379) [2.19684]	-0.041173 (0.05988) [-0.68757]
SNPK(-1)	1.035798 (0.42843) [2.41766]	0.928045 (0.16682) [5.56312]
SNPK(-2)	-0.976656 (0.44772) [-2.18139]	0.121003 (0.17433) [0.69409]
C	55.66948 (37.1883) [1.49696]	19.96889 (14.4802) [1.37904]
R-squared	0.795973	0.986912
Adj. R-squared	0.774496	0.985534
Sum sq. resids	36166.80	5483.397
S.E. equation	30.85058	12.01249
F-statistic	37.06242	716.3421
Log likelihood	-205.8103	-165.2524
Akaike AIC	9.805132	7.918715
Schwarz SC	10.00992	8.123506
Mean dependent	495.4419	392.6512
S.D. dependent	64.96604	99.87561
Determinant resid covariance (dof adj.)		122221.9
Determinant resid covariance		95450.72
Log likelihood		-368.5556
Akaike information criterion		17.60724
Schwarz criterion		18.01682

Appendix 3E

OLS ESTIMATES FROM VAR MODELLING

System: UNTITLED
 Estimation Method: Least Squares
 Date: 06/05/20 Time: 20:44
 Sample: 3 95
 Included observations: 48
 Total system (unbalanced) observations 91

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.503776	0.147995	3.404005	0.0010
C(2)	0.299172	0.147358	2.030241	0.0456
C(3)	1.025162	0.415194	2.469116	0.0156
C(4)	-0.955641	0.433090	-2.206566	0.0302
C(5)	65.80344	33.52670	1.962717	0.0531
C(6)	-0.036943	0.059800	-0.617782	0.5385
C(7)	-0.041173	0.059881	-0.687567	0.4937
C(8)	0.928045	0.166821	5.563123	0.0000
C(9)	0.121003	0.174333	0.694091	0.4896
C(10)	19.96889	14.48024	1.379043	0.1717
Determinant residual covariance		93357.96		

Equation: $NPK = C(1)*NPK(-1) + C(2)*NPK(-2) + C(3)*SNPK(-1) + C(4)*SNPK(-2) + C(5)$

Observations: 48

R-squared	0.802748	Mean dependent var	493.1250
Adjusted R-squared	0.784399	S.D. dependent var	64.61527
S.E. of regression	30.00269	Sum squared resid	38706.95
Durbin-Watson stat	2.252276		

Equation: $SNPK = C(6)*NPK(-1) + C(7)*NPK(-2) + C(8)*SNPK(-1) + C(9)*SNPK(-2) + C(10)$

Observations: 43

R-squared	0.986912	Mean dependent var	392.6512
Adjusted R-squared	0.985534	S.D. dependent var	99.87561
S.E. of regression	12.01249	Sum squared resid	5483.396
Durbin-Watson stat	2.292795		

$NPK = C(1)*NPK(-1) + C(2)*NPK(-2) + C(3)*SNPK(-1) + C(4)*SNPK(-2) + C(5)$

$SNPK = C(6)*NPK(-1) + C(7)*NPK(-2) + C(8)*SNPK(-1) + C(9)*SNPK(-2) + C(10)$

Appendix 3F

CAUSALITY FROM SUBSIDIZED NPK TO COMMERCIAL NPK

WALD TEST FOR LAGS OF SUBSIDIZED NPK

Wald Test:

Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	4.710162	(2, 43)	0.0141
Chi-square	9.420324	2	0.0090

Null Hypothesis: $C(3)=C(4)=0$

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(3)	1.025162	0.415194
C(4)	-0.955641	0.433090

Restrictions are linear in coefficients.

Appendix 3G

CAUSALITY FROM COMMERCIAL NPK TO SUBSIDIZED NPK

WALD TEST FOR LAGS OF CNPK

Wald Test:

Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	2.443921	(2, 38)	0.1004
Chi-square	4.887841	2	0.0868

Null Hypothesis: $C(6)=C(7)=0$

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(6)	-0.036943	0.059800
C(7)	-0.041173	0.059881

Restrictions are linear in coefficients.

Appendix 3H

RELATIONSHIP BETWEEN SUBSIDIZED UREA AND COMMERCIAL UREA

Vector Autoregression Estimates

Date: 06/06/20 Time: 02:32

Sample (adjusted): 3 94

Included observations: 44 after adjustments

Standard errors in () & t-statistics in []

	CUREA	SUREA
CUREA(-1)	0.842581 (0.14514) [5.80537]	-0.025104 (0.04489) [-0.55928]
CUREA(-2)	0.103051 (0.14926) [0.69041]	-0.022035 (0.04616) [-0.47735]
SUREA(-1)	1.872830 (0.51432) [3.64139]	0.944375 (0.15906) [5.93723]
SUREA(-2)	-1.827219 (0.53850) [-3.39315]	0.097235 (0.16654) [0.58385]
C	10.40678 (35.3121) [0.29471]	7.863733 (10.9208) [0.72007]
R-squared	0.846167	0.987822
Adj. R-squared	0.830390	0.986573
Sum sq. resids	63417.84	6065.554
S.E. equation	40.32491	12.47105
F-statistic	53.63056	790.8832
Log likelihood	-222.4461	-170.8095
Akaike AIC	10.33846	7.991341
Schwarz SC	10.54121	8.194090
Mean dependent	485.3636	370.8864
S.D. dependent	97.91455	107.6256
Determinant resid covariance (dof adj.)	251568.1	
Determinant resid covariance	197642.1	
Log likelihood	-393.1393	
Akaike information criterion	18.32451	
Schwarz criterion	18.73001	

Appendix 3I

OLS ESTIMATES FROM VAR MODELLING (RELATION BETWEEN SUBSIDIZED UREA AND COMMERCIAL UREA)

System: UNTITLED
 Estimation Method: Least Squares
 Date: 06/06/20 Time: 02:33
 Sample: 3 95
 Included observations: 49
 Total system (unbalanced) observations 93

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.846319	0.138743	6.099908	0.0000
C(2)	0.083870	0.141283	0.593630	0.5544
C(3)	1.911468	0.490061	3.900467	0.0002
C(4)	-1.869203	0.512643	-3.646212	0.0005
C(5)	18.05536	31.62136	0.570986	0.5696
C(6)	-0.025104	0.044886	-0.559279	0.5775
C(7)	-0.022035	0.046161	-0.477353	0.6344
C(8)	0.944375	0.159060	5.937229	0.0000
C(9)	0.097235	0.166539	0.583853	0.5609
C(10)	7.863733	10.92076	0.720072	0.4735
Determinant residual covariance		183652.6		

Equation: UREA = C(1)*UREA(-1) + C(2)*UREA(-2) + C(3)*SUREA(-1) +

C(4)*SUREA(-2) + C(5)

Observations: 49

R-squared	0.852577	Mean dependent var	480.5306
Adjusted R-squared	0.839175	S.D. dependent var	96.26788
S.E. of regression	38.60632	Sum squared resid	65579.72
Durbin-Watson stat	1.879545		

Equation: SUREA = C(6)*UREA(-1) + C(7)*UREA(-2) + C(8)*SUREA(-1) +

C(9)*SUREA(-2) + C(10)

Observations: 44

R-squared	0.987822	Mean dependent var	370.8864
Adjusted R-squared	0.986573	S.D. dependent var	107.6256
S.E. of regression	12.47105	Sum squared resid	6065.554
Durbin-Watson stat	2.309775		

NOTE:

UREA = C(1)*UREA(-1) + C(2)*UREA(-2) + C(3)*SUREA(-1) + C(4)*SUREA(-2) + C(5)

SUREA = C(6)*UREA(-1) + C(7)*UREA(-2) + C(8)*SUREA(-1) + C(9)*SUREA(-2) + C(10)

Appendix 3J

CAUSALITY FROM SUBSIDIZED UREA TO COMMERCIAL UREA

WALD TEST FOR SUBSIDIZED UREA

Wald Test:

Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	8.757442	(2, 44)	0.0006
Chi-square	17.51488	2	0.0002

Null Hypothesis: $C(3)=C(4)=0$

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(3)	1.911468	0.490061
C(4)	-1.869203	0.512643

Restrictions are linear in coefficients.

Appendix 3K

CAUSALITY FROM COMMERCIAL NPK TO SUBSIDIZED NPK

WALD TEST FOR UREA

Wald Test:

Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	1.316736	(2, 39)	0.2797
Chi-square	2.633472	2	0.2680

Null Hypothesis: $C(6)=C(7)=0$

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(6)	-0.025104	0.044886
C(7)	-0.022035	0.046161

Restrictions are linear in coefficients.

Appendix 4A

QUESTIONNAIRES

5/6/2020

Value Chain analysis (Farmers)

Value Chain analysis (Farmers)

Enter a time hh:mm
Community
Region
Gender <input type="radio"/> Male <input type="radio"/> Female
1.0 Farm Attributes
1.1 Number of farm employees
1.2 Are you a member of a cooperative/association ? <input type="radio"/> Yes <input type="radio"/> No
1.3 If Yes, kindly list the cooperatives/associations you are a member.
1.4 Are you a commercial farmer or subsistence farmer ? <i>A subsistence farmer produces for to meet family consumption/needs only.</i> <input type="radio"/> Commercial <input type="radio"/> Subsistence
1.5 What is the size of your household?
1.6 How old are you?

1.7 Do you own your farmland?

Yes

No

1.8 What is your total farm size ?

(Acres)

1.9 What is the total farm size fertilizer was applied

1.10 Do you have a storage facility for your products?

Yes

No

1.11 If Yes, how many 50kg bags can it hold?

1.12 How many years have you been farming?

1.13 Do you have other businesses aside from farming?

Yes

No

1.14 If Yes, kindly list other off-farm businesses.

1.15 Have you received any form of agricultural training?

Yes

No

1.16 If Yes, kindly list the organizations that organized the trainings and the types of trainings.

1.17 Do you own a smart phone or computer?

Yes

No

1.18 How do you rate your skills in using technology e.g smart phones and computers?

- Very good
 Good
 Average
 Bad
 Very bad

1.19 What is your highest education level?

- Tertiary
 High School
 Primary School
 None

2.1 Do you have access to subsidized fertilizers?

- Yes
 No

2.2 Do you purchase commercial fertilizers?

- Yes
 No
 Option 3

2.3 What quantity of subsidized fertilizers do you purchase (50kg bags)?

2.4 Kindly list the types and prices of subsidized fertilizers you purchase.	Name of commercial fertilizers	Quantity (50kg bags)	Unit Price	Source (retailer/wholesaler and name)
1				
2				
3				
4				

5				
2.5 Kindly list the types and prices of commercial fertilizers you purchase.	Name of commercial fertilizers	Quantity	Unit Price	Source (retailer/wholesaler and name)
1				
2				
3				
4				
5				

2.6 Where do you purchase your fertilizers (towns/cities)?

2.7 How many minutes does it take you to get to the fertilizer market?

2.8 How much does it cost you to transport the fertilizers to the farm (GHS)?

2.9 Do you own any of these vehicles for farm use?

tick as many as possible

- truck
- Car
- Tricycle
- Bike

2.10 Do you own livestock?

- Yes
- No

2.11 Do you apply animal manure?

- Yes
- No

2.12 Is your farm irrigated?

- Yes
- No

2.13 Kindly list the crops, varieties, quantity of fertilizer used and commodity prices.	Crop	Farm size	Output (50kg bags)	Variety cultivated	Type and quantity of fertilizer	2019 commodity market price	2020 commodity market price
1							
2							
3							
4							
5							

2.14 What is the total quantity of fertilizers you use in a year (50kg bags)?

2.15 What determines the quantity of fertilizers you utilize ?

2.16 How much do you spend on fertilizers in a year (GHS)?

2.17 How much do you spend on other farm inputs e.g. seeds, pesticides etc (GHS)?

2.18 How much do you spend on labour (GHS)?

2.19 Please list additional costs and amount you incur aside from cost of fertilizers, seeds, pesticides and labour?

2.20 Do you have off-takers or a ready market for your commodities?

- Yes
 No

3.1 Do you need additional finance for your farm business expansion?

- Yes
 No

3.2 Have you had access to finance before?

- Yes
 No

3.3 If No, what are the reasons for not accessing credit?

3.4 Are you currently on loan?

- Yes
 No

3.5 What is the average loan amount you access (GHS)?

3.6 What is the cost of loan application fee (GHS)?

3.7 What is the average loan interest rate per year (%)?

3.8 What is the average loan tenor/duration?

- 1-3 months
 3-6months
 6-9months
 9-12months
 12months and above

3.9 Cost of collateral evaluation if applicable (GHS)?

3.10 How many trips do you make to the bank before accessing credit ?

3.11 Cost of single trip to bank (to and from)?

3.12 How much upfront charge is requested before access to credit (GHS)?

3.13 Kindly list others cost associated with credit access and their amount (GHS).

3.14 Kindly indicate the ease at which you access credit?

- Very easy
- Easy
- Sometimes
- Difficult
- Very Difficult

3.15 What are the constraints you face in increasing your fertilizer use?

3.16 What is the average loan amount you need to expand your fertilizer business (GHS)?

3.17 Rank the following challenges associated with credit access according to severity (1-5)

1st choice *

- Collateral High interest rate late approval
- Bank is too far Trips to bank Gratification & bribes

2nd choice *

- Collateral High interest rate late approval
- Bank is too far Trips to bank Gratification & bribes

3rd choice *

- Collateral High interest rate late approval
- Bank is too far Trips to bank Gratification & bribes

3.18 How far is the bank from you (Minutes)

3.19 Do you own a fixed asset e.g. land, house etc.?

- Yes
- No

4.0 Fertilizer Market

4.1 Do you buy fertilizers on credit?

- Yes
- No

4.2 If YES, what is the average duration of repayment

- 1-3month
- 3-6months
- 6-12months
- 12months ans above

4.3 Is there an additional cost when you buy fertilizer on credit?

- Yes
- No

4.4 What is the average additional cost when you buy fertilizers (50kg bag) on credit (GHS)

4.5 How long does it take to sell your commodities (months)?

4.6 Which fertilizer product/company do you prefer and why?

5.0 What fertilizer challenges do you face as a farmer ?	Challenges	Solutions
1		
2		
3		
4		
5		

5.1 Are you aware of the COVID-19 pandemic?

Yes

No

5.2 How has the COVID 19 pandemic affected your farming business?

5.3 In your opinion, what is the role of fertilizer application in responding to the impacts of COVID-19?

Fertilizer value chain analysis (Distributors/retailers)

Enter a date and time

yyyy-mm-dd

hh:mm

Community

Region

Gender

- Male
- Female

1.1 Number of employees

1.2 What is your highest level of education?

- Tertiary
- High school
- Primary School
- None

1.3 How old is your firm?

1.4 Do you have a license to operate?

- Yes
- No

1.5 List other non-fertilizer businesses/income you engage in.

e.g. seeds, pesticides, farming, carpentry, transportation, public servant etc.

1.6 What category of the fertilizer distribution network do you belong?

- Distributor
- Retailer
- Importer
- Blender

1.7 What is your sales volume in a year (50kg bags)?

- 100-500
- 500-1000
- 1000-5000
- 5000-10000
- 10000-20000
- 20000-50000
- 50000-100,000
- 100000-above

1.8 Have you received any training on fertilizer management etc.?

- Yes
- No

1.9 If Yes, how many trainings have you received ?

1.10 Do you own a smart phone or a computer?

- Yes
- No

1.11 How do you rate your skills when using technology e.g smart phones and computers?

- Very good
- Good
- Average
- Bad
- Very bad

2.0 Fertilizer Storage

2.1 Do you own or rent your storage space?

Kindly tick one of the options below

- Own
 Rent

2.2 What is your total fertilizer storage capacity (50kg bags)?

The total number of bags your store can contain at a time

2.3 What is your average utilized storage capacity for fertilizers?

The average number of 50kg bags in your store

2.4 What is the cost of renting your storage facility in a year (GHS)?

2.5 Do you own a fixed asset e.g land or house?

- Yes
 No

Fertilizer Transportation

3.1 Do you transport fertilizers yourself or you share cost with others?

- Sole transporter of fertilizer
 Cost sharing with supplier
 Cost sharing with other actors
 Cost sharing with importers

3.2 Are you willing to share/collaborate with other players in fertilizer transportation e.g. retailers and distributors to increase your profitability?

- Yes
 No

3.3 Where do you buy your fertilizers (Name/town/city)?

3.4 How many minutes of travel does it take you to get to where you purchase your fertilizers?

3.5 What is the maximum truck capacity available for transporting fertilizers in the market (50kg bags)?

3.6 What is the actual average quantity of fertilizer you purchase at a time (50kg bags)?

The average quantity per trip

3.7 How much does it cost you to transport your fertilizers to your store (GHS)?

3.8 How much is your handling cost (loading and offloading) in GHS?

3.9 Where do you supply your fertilizers (communities/towns)?

3.10 How many minutes away are you from towns and cities you supply fertilizers?

Convert hours to minutes

4.0 Fertilizer Sales

4.1 Do you buy fertilizers on credit?

Yes

No

4.2 If Yes, what is the average repayment duration?

4.3 Do you sell fertilizers on credit?

Yes

No

4.4 If Yes, what is the average repayment duration?

1-3months

3-6months

6-12months

12months and Above

4.5 If YES, what is the default rate (%)?

4.6 Do you sell fertilizers in kind?

Yes

No

4.7 If Yes, Kindly specify what forms of payments you collect

4.8 What is the price of these fertilizers when you pay on the spot (Ghc)?	Commercial Spot purchasing prices	Subsidized Spot purchasing Prices
NPK 23 10 5 + 2MgO + 3S + 0.3ZN		
NPK 25 10 10 + 3S + 3MgO + 0.3Zn		
NPK 15 20 20 + 0.7Zn		
10. SoA		
NPK (15:15:15)		
NPK 11 22 21 + 5S + 0.7Zn + 0.5B		
NPK 20 10 10 + 3S		
NPK 12 30 17 + 0.4Zn		
KCl		
Urea		
Other		
4.9 What is the additional cost when you buy fertilizer on credit (GHS)?		
4.10 How much do you sell these fertilizers under the following circumstances?	Commercial Fertilizers Spot Selling Price	Spot Selling Prices for a 50kg bag of Subsidized Fertilizer
NPK 25 10 10 + 3S + 3MgO + 0.7Zn		

SoA		
NPK 23 10 5 + 2MgO + 3S + 0.3ZN		
NPK (15:15:15)		
NPK 11 22 21 + 5S + 0.7Zn + 0.5B		
NPK (23:10:10)		
NPK 20 10 10 + 3S		
NPK 15 20 20 + 0.7Zn		
Urea		
KCl		
NPK 12 30 17 + 0.4Zn		
4.11 What is the additional cost when you sell fertilizer on credit (GHS)?		
4.12 List the top 5 selling fertilizers by volume?	Type of fertilizer	Why
1		
2		
3		
4		
5		

5.0 Credit and Finance
5.1 What is your net evaluation of your fertilizer business?
5.2 Are you currently on loan? <input type="radio"/> Yes <input type="radio"/> No
5.3 Have you had access to loan from a bank/finance institution for your fertilizer business? <input type="radio"/> Yes <input type="radio"/> No
5.4 If No, What are your reasons for not accessing credit?
5.5 Do you engaged in informal borrowing? <input type="radio"/> Yes <input type="radio"/> No
5.6 If Yes, please specify source of borrowing?
5.7 What is the average loan amount you need for your fertilizer business (GHS)?
5.8 How often do you get the loan amount you applied for? <input type="radio"/> Often <input type="radio"/> Seldomly <input type="radio"/> Never
5.9 How much is the loan application fee, upfront etc.?
5.10 What is the average interest rate per year for loans you have accessed?

5.11 What is the average loan tenor/duration

- 1-3months
 3-6months
 6-9months
 9-12months
 12months and Above

5.12 What is the average cost of collateral required to access loan?

5.13 What is the cost of collateral valuation/paper works?

5.14 How many trips do you make to the bank before credit is approved?

5.15 What is the cost of a single trip to the bank (GHS)?

5.16 Please indicate other costs and amount associated with access to credit (GHS)?

5.17 Kindly select an option below according to ease of credit access.

- Very easy
 Easy
 Sometimes
 Difficult
 Very difficult

5.18 Kindly rank these challenges according to severity

1st choice *

- collateral High interest rate banks are too far
 Loan amount is too small High upfront charges Bribes & gratifications

2nd choice *

- collateral High interest rate banks are too far
 Loan amount is too small High upfront charges Bribes & gratifications

<p>3rd choice *</p> <p> <input type="radio"/> collateral <input type="radio"/> High interest rate <input type="radio"/> banks are too far <input type="radio"/> Loan amount is too small <input type="radio"/> High upfront charges <input type="radio"/> Bribes & gratifications </p>		
<p>4th choice *</p> <p> <input type="radio"/> collateral <input type="radio"/> High interest rate <input type="radio"/> banks are too far <input type="radio"/> Loan amount is too small <input type="radio"/> High upfront charges <input type="radio"/> Bribes & gratifications </p>		
<p>5th choice *</p> <p> <input type="radio"/> collateral <input type="radio"/> High interest rate <input type="radio"/> banks are too far <input type="radio"/> Loan amount is too small <input type="radio"/> High upfront charges <input type="radio"/> Bribes & gratifications </p>		
<p>5.19 Do you need additional finance to expand your fertilizer business?</p> <p> <input type="radio"/> Yes <input type="radio"/> No </p>		
<p>5.20 If you get additional finance how would it help your fertilizer business?</p> <p>.....</p>		
<p>5.21 What is the average loan amount you need for your fertilizer business expansion?</p> <p>.....</p>		
<p>6.1 How is your book keeping records?</p> <p><i>If records for the last 10 years exist =very good</i></p> <p> <input type="radio"/> Very Good <input type="radio"/> Good <input type="radio"/> Average <input type="radio"/> Bad <input type="radio"/> Very Bad </p>		
<p>7.0 What are your challenges in the fertilizer market and what can be done to address them?</p> <p>.....</p>	<p>Challenges</p> <p>.....</p>	<p>Solutions</p> <p>.....</p>
<p>1</p> <p>.....</p>	<p>.....</p>	<p>.....</p>
<p>2</p> <p>.....</p>	<p>.....</p>	<p>.....</p>

3
4
5
7.1 How has the recent COVID-19 pandemic affected your business?		
7.2 What is your fertilizer is your fertilizer market perception and future outlook?		

1			
2			
3			
4			
5			
6			
7			
2.3 What is the average quantity of fertilizer you import in a year (tonnes)?			
2.4 What is your cost of blending a ton of fertilizer (GHS)?			
2.5 What is your installed blending capacity (tonnes)?			
2.6 What is your average operating capacity (tonnes)? <i>Before Covid-19</i>			
2.7 What is your current operating capacity (tonnes)?			
2.8 What is your maximum storage capacity (tonnes)?			
2.9 What is the average storage capacity in a month (tonnes)?			

2.10 Kindly indicate your business peak period (months)?

- January
- February
- March
- April
- May
- June
- July
- August
- September
- October
- November
- December

2.11 What is your peak capacity (tonnes)?

2.12 Are you willing to collaborate or share storage facilities with other industry actors to increase profitability?

- Yes
- No

2.13 Kindly list the fertilizer formulations you blend	Formulas	Volume
Row		
1		
2		
2		
4		
5		
6		

3.0 Transportation/Distribution
3.1 Do you collaborate and partner with other importers to ship fertilizers? <input type="radio"/> Yes <input type="radio"/> No
3.2 If No, Why?
3.3 Would you like to collaborate and partner with other importers in shipping fertilizers to increase your profitability? <input type="radio"/> Yes <input type="radio"/> No
3.4 Do you own trucks for transportation? <input type="radio"/> Yes <input type="radio"/> No
3.5 If yes, how many trucks do you own?
3.6 Are you willing to collaborate or outsource your logistics in order to increase your profitability? <input type="radio"/> Yes <input type="radio"/> No
3.7 Kindly indicate your fertilizer distribution channels <input type="checkbox"/> PFJ <input type="checkbox"/> Plantations <input type="checkbox"/> Open market <input type="checkbox"/> COCOBOD
3.8 Do you have warehouses in all 16 regions in Ghana? <input type="radio"/> Yes <input type="radio"/> No
3.9 If No, kindly list the regions you own warehouses and distribution network? <i>Regions/districts</i>

3.10 Kindly specify the prices of the following fertilizers for 2020 and 2019	2020 Subsidized Fertilizers Prices	2020 Commercial Fertilizers Prices	2019 Subsidized Fertilizers Prices	2019 Commercial Fertilizers Prices
NPK 12 30 17 + 0.4Zn				
NPK 11 22 21 + 5S + 0.7Zn + 0.5B				
NPK 20 10 10 + 3S				
NPK (15:15:15)				
NPK 25 10 10 + 3S + 3MgO + 0.7Zn				
Others				
NPK 15 20 20 + 0.7Zn				
KCl				
SoA				
NPK 23 10 5 + 2MgO + 3S + 0.3ZN				
NPK (23:10:10)				
Urea				

3.11 Who or what determines the price at which fertilizers are sold

e.g government, international markets, demand, etc.

3.12 List the 5 top selling commercial fertilizers by volume in descending order

Commercial Fertilizers (1-5)

Column

1

2

3

4

5

3.13 What is the average duration for government subsidy repayment?

- 0-3months
 3-6months
 6-9months
 9-12months
 12months and above

3.14 How does the repayment affect your business?

3.15 Do you supply fertilizer on credit?

- Yes
 No

3.16 Is there an extra cost added when fertilizer is supplied on credit ?

- Yes
 No

3.17 If Yes, what is the average extra cost on a 50kg bag of fertilizer (GHS)?

3.18 If Yes, what is the average duration of repayment?

0-3months

3-6months

6-12months

12months and above

3.19 What is the default rate on fertilizers supplied on credit (%)?

3.20 Do you sell to FBOs and NGOs?

Yes

No

3.21 Kindly list the names, contacts and regions of your major distributors.	Names/contacts	Region/district
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

4.0 Business financing		
4.1 Do you have access to credit?		
<input type="radio"/> Yes <input type="radio"/> No		
4.2 If yes what is the average loan duration?		
<input type="radio"/> 0-3months <input type="radio"/> 3-6months <input type="radio"/> 6-12months <input type="radio"/> 12 and above		
4.3 What is the average interest rate you get when you access credit (%)?		
<hr/>		
4.4 Kindly list additional cost and amount attached to access to credit (GHS)?		
<hr/>		
4.5 How much does it cost to get a letter of credit (GHS)?		
<hr/>		
4.6 Rank the following challenges associated with access to credit according to severity (1-5).		
1st choice *		
<input type="radio"/> High interest rate	<input type="radio"/> Trips to the bank	<input type="radio"/> Collateral
<input type="radio"/> Upfront charges	<input type="radio"/> Bribes & Gratification	<input type="radio"/> Late Approval
<input type="radio"/> Hidden Charges		
2nd choice *		
<input type="radio"/> High interest rate	<input type="radio"/> Trips to the bank	<input type="radio"/> Collateral
<input type="radio"/> Upfront charges	<input type="radio"/> Bribes & Gratification	<input type="radio"/> Late Approval
<input type="radio"/> Hidden Charges		
3rd choice *		
<input type="radio"/> High interest rate	<input type="radio"/> Trips to the bank	<input type="radio"/> Collateral
<input type="radio"/> Upfront charges	<input type="radio"/> Bribes & Gratification	<input type="radio"/> Late Approval
<input type="radio"/> Hidden Charges		

4.7 What are your challenges in the fertilizer market and what can be done to address them?	Challenges	Solutions
1		
2		
3		
4		
5		
5.0 COVID-19		
5.1 What is the challenges of the COVID 19 Virus on your business and what can be done to address these challenges??		
5.2 What is your fertilizer market perception and future outlook?		
The Ghana customs authority (GCA) IFDC report for 2018 claims the cost of 1mt bagged Urea at the port of Tema is \$394.20		
5.3 Do you agree with the cost? <input type="radio"/> Yes <input type="radio"/> No		
What is the cost for 2020, especially in the wake bagging 25kg as compared to 50 kg bags		
5.4 How many days does it take you to clear your fertilizers at the port?		
5.5 How much do you pay for demurrage per day		
5.6 How long does subsidy repayment take ?		