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Moderating Effect of Cost of Information Technology Adoption and Utilization on the Relationship Between Cost of Sugarcane and Food Production Among Farming Agribusinesses in Nyanza Region, Kenya

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Abstract

Climate change has hampered the predictability of the weather patterns across the globe. This has occasioned lack of preparedness and better planning for coping and adaptability among farming agribusinesses. Inadequate farm output, low income and food insecurity are their outcome since drought and flood episodes are the dominant consequences of adverse climate change. Developing nations that have adopted and utilized information correctly such as India and Brazil have realized high yields and income through reduced costs of inputs, hence minimizing food insecurity. Although weather information is often disseminated to Kenyans and given the existing remarkable agricultural information dissemination channel through electronic media, Nyanza region still suffers from low agricultural output. It is unclear whether the problem is one of cost of adoptions and utilization of the media or it is the packaging of agricultural information. Literature is also scanty on how the cost of technology adoption and utilization moderates the relationship between sugarcane production costs and food production costs. Guided by the Cost Minimization Theory, this study used cross-sectional primary data collected from 317 sugarcane and food (maize) crop farmers selected through a multistage random sampling. Multinomial logit regression was used analyse any existing moderating effect within the study area. Findings show that only cost of technology adoption negatively and significantly influenced the cost of sugarcane production. Results further indicate that as a moderator, the cost of weather information adoption was not significant in influencing the factors of production in either maize or mixed production but was being absorbed negatively and significantly into the cost of land in sugarcane production. Since the adoption of agricultural information is usually hampered by a lack of logistics, downscaled information, and confidence, capacity-building of farmers must be mainstreamed. Hence, the need for extension services advocacy on the use of technology in agriculture.

Keywords: Cost of food production, cost of sugarcane production, information adoption, information utilization, multinomial logit regression

Introduction

Climate change is the protracted changes in temperatures and weather patterns over time (Human Rights Watch, 2023). The main causes of climatic change results from human activities or actions such as burning of coal, gas and oil. Emissions from these fossil fuels trap the heat from the sun resulting into high temperatures. When it happens, effects to humanity survival are dire since there emerges less or

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no rainfall, food insecurity, famine, severe drought, urban displacements, flooding, air pollution, infrastructure destruction and injurious effects on health. Climate change is able to disorder food access, its availability as well as its quality especially when temperatures rise, precipitation patterns changes, drought emerges and also when weather events become extreme, (United States Environmental Protection Agency [EPA], 2023).

The Kenya Meteorological Department [KMD] (2020) has observed that such devastating effects from climatic changes, require proper adaptation and mitigation measures, given a bimodal seasonal rainfall pattern (short and long rains), agricultural production – a significant sector contributing to 26 percent of the Gross Domestic Product (GDP) and another 27 percent of GDP indirectly through linkages with other sectors – requires the long rains. Despite accessibility of early warning systems, information advances in science, data and technology; individuals, communities, governments, humanitarian organizations and international donor agencies, are reactive to climate change effects (Kenya Red Cross, 2020). Therefore, the provision of timely and accurate weather information can lower the susceptibility of farmers to climate change risks.

Given that climate change causes extreme weather patterns and drought, food security become doubtful. With information technology adoption and utilization, precision agriculture becomes a reality. Because sugarcane farming has a positive relationship to maize farming and such relationship is complementary (Wiggins et al., 2015), this study seek to establish whether information technology has an effect on this relationship from the perspective of the factors of production on both crops. These costs included the cost of technology gadget acquisition (adoption) and the cost of use (utilization) to acquire agricultural information on renting land, labour, planting, fertilizers, pesticides, seed(ling), transport, weather and machinery (Ochieng & Onyuma, 2023).

Information Communication and Technology (ICT) development has had significant relevance on individuals and families due to its incorporation into the family life and in work. This is because of their acquisition and ownership (adoption) and their subsequent use (utilization). Because of the importance of information technology adoption and utilization in agriculture, countries such as India and Bangladesh, who have adopted and utilized information, have seen remarkable improvements in their levels of income and yield; increasing by 15.2 percent and 15 percent respectively (Raj et al., 2011; UNCTAD, 2012). Although the levels of information channels in Kenya are incredible (KNBS, 2011), farming agribusinesses are still experiencing low productivity and grapples with limitations in management, technology as well as economic concerns (Mati & Thomas, 2019). Besides minimal studies on role of cost of information technology adoption and utilization in agricultural practices (Kwadwo & Mekonnen, 2012), it is not clear whether it is the cost of adoption or it is cost of utilization of information that is hindering agricultural information to increase agricultural production.

Adoption denotes the stage in an organization where a family or an individual selects a technology for use (Adeoye & Adeoye ,2010). From Bridges to Technology Corp (2005), technology adoption begins with the user becoming cognizant of the technology, and ends when the user embraces the technology and completely uses it. Anybody who embraces technology is likely to find innovative uses for it, replace it should it break and cannot envisage life without it. For any technology to be adopted, awareness must be produced and distributed through electronic media, radio and television (Nnadi et al., 2012). However, the absence of education, training and information will limit the level of technological adoption by farming agribusinesses especially in low-income countries (Springer, 2001; Wongsim et al., 2018). On the flipside, Akuegwu (2015) views technology utilization as the ability to use technological resources to achieve instructional

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objectives in a given situation. In this study, information adoption and utilization involve the cost of acquisition and cost of use of television, internet, radios, geographical information services, computers and cell phones to acquire agricultural information meant towards increasing agricultural productivity.

Interest to study the cost of information adoption and utilization is based on the concept of utility theory that emphasizes on the need to have perfect information or full knowledge of all the relevant information for the theory to hold. Better still, adoption and utilization of information technology aid in precision agriculture (Agricultural Research Service [ARS], 2022). Satisfaction is often achieved when the marginal utilities are equal to the marginal rate of commodity substitution. This is only possible when marginal cost in the production process equals to the marginal revenue received from the sales per unit (Staff, 2016). Meanwhile, interest towards studying cost of sugarcane production and cost of food production stemmed from Wiggins et al. (2015) argument that sugarcane, an industrial crop, is complementary to food crops. Therefore, the system of organizing the factors of production between sugarcane and food crop production depends on the level of information at the behest of the farming agribusinesses (Riley, 2011).

This study was pegged on the cost minimization theory which states that the cost of a product is a combination of the cost of the physical output as well as the cost of the factor input that went into its production (Ebele & Nneamaka, 2018). Given that the focal point of this study targeted 2 products that can either be complementary or substitutes, the options at the behest of the farming agribusinesses greatly depend on the minimal cost of production and the profits that each output elicits. However, access to such costs depends on the information flow through information technologies.

Specifically, this study assessed how the costs of inputs varied between food production and sugarcane production on the assumption that cost was minimized through factor substitution and that the possibility of such substitution also depended upon the relative price level of the various factors. Based on the rationality of the household behaviour (Mausch et al., 2018), the general assumption was that there is a combination of both food production and sugarcane production that can be done simultaneously to make a farmer or society better off and beyond a certain point, any increase in the cost of sugarcane production led to a total shift towards food production and vice versa. Given this assumption, the study explored the role of information adoption and utilization to gauge whether such points can shift (moderate) because in the production possibility frontier, technology is always held constant while other factors of production are varied.

Literature Review

In the theory of production, a shift in the production possibility frontier is as a result of changes in the level of technology, influenced by the level of perfect information of the producer (Corporate Finance Institute[CFI], 2021). Information on improved technologies can only be availed to the farming agribusinesses (producers) through the information gadgets such as radios, televisions, mobile phones as well as computers (Alila & Atieno, 2006). Unless farmers adopt and make use of these technologies, they may therefore not be able to increase their agricultural productivity (Doss, 2006).

In context, this study views information adoption and utilization as a mixture of both soft and hardware and how they interact to permit the interchange, processing and control of knowledge and information through the use of radios, computers, televisions, cell phones, and the like (O’Farrell, 2015). In order to improve agricultural endeavours, there should be an improvement in

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the use of computers, remote sensing, internet, cloud computing, GIS and GPS (Food and Agriculture Organization, 2016).

Incorporating information adoption and utilization in this study, was premised on the suggestion that the only way to address global challenge on food production is to adopt the digital or green revolution (Marke, 2014) to meet the ambitious food productivity targets. Marke, (2014) established that changes in climatic conditions, diminishing agricultural supply, increase in population, diminishing land and water supply coupled with changes in trade policies among the trading partners, are some of the major reasons why nations need to rethink their food production requirements. ICT penetration in Kenya, has expanded from 10 percent to 22 percent in 2017 and has contributed to 1.6 percent of GDP in 2018. Mobile phone adoption increased to 91 percent while penetration rate rose to 84 percent (Jumia, 2019). Given these statistics, Raj et al. (2011) observed that mobile phones intervention is capable of increasing the farmers' fortunes. The truism of this statement prompted the examination of the existence of the evidence on their moderating effect on the cost of sugarcane production and cost of maize production among farmers in Nyanza region in Kenya.

In China, Daoliang (2017) ascertained that provision of information serves to encourage the use of agricultural technology processing thus the provision of openings and platform for knowledge swapping among farmers. Besides, they also help in creating and promoting professional groups for agro-meteorological database development, livestock and crop modelling. While referencing Dike (2007), Gwang (2011) established those advances and globalization in technology in the 21st century helps in increasing the speeding and the exactness at which information is transferred, accessed, produced or even used in production. Besides, the author noticed that the use of information also elevates the position, the influence, the wealth and power of any given nation.

Abdul-Salam and Phimister (2015) studied the effect of information access efficiency on smallholder farming agribusinesses in Uganda. Their conclusion was that information access is significant in increasing agricultural productivity. However, Singh et al. (2019) observed that information is still lacking among farmers engaged in the production of vegetables and sugarcane in north-central India. As a result of this, most farmers still experience increase in costs of production given that they are still using the primitive equipment. However, with faster adoption and dissemination of new and improved technologies, sugarcane production can improve (Chauhan & Shanthy, 2021).

With changes in information technology in the agricultural sector, there may be improvements in the overall output in sugarcane production as well as food crop production. Ncoyini et al. (2022) observed that information relating to climate change are majorly used by the commercial sugarcane farming agribusinesses as opposed to the small scale farmers. According to Mileff (2015), computers alongside other telecommunication gadgets can be used in agriculture to store, retrieve, transmit or manipulate data in order to increase the level of efficiency in production. If information technologies are used well, then farming agribusinesses can make better decisions, plan better, realize agricultural breakthroughs and also improve community participation (IBID, 2015).

Similarly, myriad of challenges in the agricultural sector such as price fluctuations, deregulation of the agricultural market as well as volatility in the export market can be addressed through information use (Muriithi et al., 2009; Dobermann & Nelson, 2015). However, Jack and Tobias (2017) observed that information alone is not a cure to problems bedevilling farming agribusinesses. It is a means of helping agribusinesses to make informed decisions on agricultural

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inputs, selection of the best practices as well as offer farmers a bargaining power when interacting with buyers-thus-transforming agricultural productivity. Kwadwo and Mekonnen (2012) also concluded that although very little has been done in terms of the impact of ICT in agriculture, its use in Africa has a potential of transforming the socio-economic environment.

Ali et al. (2016) studied the impact of ICTs on agricultural productivity in Kapiri Mposhi district of Central Province in Zambia. Using a multiple stage random sampling technique among 117 farmers as well as OLS method to generate results, it revealed that ICT usage was positive yet insignificant in affecting agricultural productivity. However, in the current paper, structural equation modelling (SEM) was applied to generate more robust results as opposed to ordinary least square (OLS) method of estimation. In addition, Raj et al. (2011) investigated the use of mobile phone short messaging service (SMS), voice call or web pages on the livelihoods of farmers in Nagapattinam district, Tamil Nadu state of India. They did this through customizing crop cultivation and nutrients management among the farmers. Their results showed that ICT use substantially reduced farmers' costs and also improved their farming practices. Compared to the control group, there was a 15.2 percent rise in income among the intervention group besides reduction of costs in terms of seeds, nutrient management, nursery preparation and weeding. Although their study focused on the pre-harvest stage, the current study focused on both pre-harvest and post-harvest stages.

In Kenya, apart from the traditional radio and television programmes that were used to disseminate information to farmers, other initiative such as 'Seeds4needs' was launched in 2009. This is an electronic farming method which was piloted in 2011 and used text messages to give advice to farmers on different hardy crop varieties, fertilizer use as well as crop management. The other available e-platform is the M-farm which has provided smallholder farmers with market pricing information through an SMS or mobile phone application. Since these initiatives began, only 5000 farmers have registered and the results have shown that farmers using them have realized a double rise in returns (Marke, 2014). However, the report noted that the adoption and utilization of such a technology can be low if no funds or resources are devoted to their implementation. The inclusion of information adoption and utilization that this study preferred was as a result of such e-platforms to gauge the platforms' level of use among farmers in Nyanza region.

Usman and Ahmad (2018) investigated the role of learning as a mediator in the relationship between social capital and the adoption of best crop management practices among farmers in Pakistan. This investigation was done on small scale farmers and a structural equation modelling as well as bootstrapping was used to test these relationships. From the results, it was evidenced that explorative and exploitative learning directly acted as mediators between social capital and adoption of best crop management practices but did not moderate between social capital and adoption of best crop management practices. According to IBID (2018), exploitative learning inferred the refinery of the existing practices, processes, products, technologies and competencies without changing their nature while explorative learning involved the search and experimentation of the existing practices, processes, products, technologies and competencies. Although this study adopted a similar methodology to that of IBID (2018), the point of divergence was that the current study investigated the costs related to the search for this knowledge. Besides, these costs were investigated against costs of two competing agricultural outputs.

Wang et al. (2018) examined how farmers' application of pesticides are influenced by the market returns and external pressure in China. They also investigated the moderating role of information acquisition into this mix. While using a multistage sampling method among 986

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farmers, a hierarchical regression analysis was conducted to test the hypothesis. Their results indicated that there was a positive and significant effect on market returns, pesticide application and information acquisition. Similarly, there was also a positive effect between external pressure and application of information on pesticide acquisition. Although information acquisition and its moderating ability were investigated by Wang et al. (2018), this current study examined the cost of acquisition and the cost of utilization. Besides investigating how this information was used in the application of pesticides, an extension was done to cover other phenomena in agricultural production such as marketing and labour choices among others.

Ismail et al. (n.d) investigated the effect of economic indicators on agricultural productivity and the moderating role of support policies. Their main interest was to establish the relationship between agricultural input and output and the clear determinants of agricultural growth. This study was conducted in Malaysia and the ASEAN countries. The economic indicators investigated were the physical and human capital used in agriculture while support policies were proxied by farmer training, research and development as well as fertilizer subsidy. In their results, it emerged that support policy positively moderated the relationship between physical capital and agricultural productivity. Similarly, support policy also moderated the positive relationship between human capital and agricultural productivity. They recommended that future research should be done using primary data. They further recommended the inclusion of other variables that enhance agricultural productivity such as technology and innovations. Based on their recommendations, the current study incorporated primary data and investigated the moderating effect of cost of information adoption and utilization on the cost of sugarcane and maize crop production.

Methodology

This study was conducted in 3 agricultural areas (Kisumu, Homabay and Migori) of Nyanza region in Kenya. It adopted the correlational research design to determine the moderating effect of cost of information adoption and utilization on the relationship between the cost of sugarcane and food (maize) production. After assessing the mentioned crops separately, the study was amplified to cover the cost of mixed production. A multistage random sampling was adopted to select 317 farming households (both sugarcane and maize crop) who had an experience spanning above 5 years. Data collected through questionnaires were tested for heteroscedasticy, content validity and reliability using Levene’s test, experts’ opinion and Cronbach’s alpha, respectively.

Through multinomial logit, farmer-type was coded as follows: ‘Sugarcane only’ farming was coded (1), mixed farming was coded (2) while ‘maize only’ farming was coded (3). Given the 3 farmer types, cost estimates were considered separately for the 3 outputs. The functional form of the equation without cost of adoption or cost of utilization was conceptualized in Equation 1:

$$\ln TC_{(S_i,F_i)} = \delta_0 + \delta_1 \sum_{(f,s)=1}^{n} \ln(L_{fi} + L_{si}) + \delta_2 \sum_{(f,s)=1}^{n} \ln(K_{fi} + K_{si}) + \delta_3 \sum_{(f,s)=1}^{n} \ln(D_{fi} + D_{si}) + u_{(f,s)i} \ldots\ldots.(1)$$

Where;

$\ln TC_{(S_i,F_i)}$ = The total cost of sugarcane and maize crops production per yield from an individual farming agribusiness;

$\ln(L_{fi} + L_{si})$ = The overall labour cost in sugarcane and maize crops production;

$\ln(K_{fi} + K_{si})$ = The overall cost of capital in sugarcane and maize crop production;

$\ln(D_{fi} + D_{si})$ = The overall cost of land in sugarcane and maize crop production;

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$\delta_1, \delta_{2,} \delta_3$ =The coefficients of costs of labour (wages), capital (input costs) and land (rents/purchase price) used in sugarcane production and maize production respectively;
$u_{(f,s)i} \sim N(0, \sigma^2{}_{u(f,s)})$ = The error term;
fi = Individual maize farming agribusiness;
si = Individual sugarcane farming agribusiness.
$fi + si$ = Mixed farming agribusiness

From Equation 1, in the absence of sugarcane, the cost is zero and vice versa. However, in the case of mixed production, the cost of sugarcane or maize crop production are added together. Operationalization of cost of information adoption and utilization as a moderator on the cost of sugarcane production and cost of maize production was done in 3 phases.

In the 1st phase, cost of information 'adoption only' was considered. The functional equation with cost of adoption was given by equation (2) whereas the functional with cost of information adoption introduced as a moderator transformed Equation 2 into Equation 3.

$$\ln TC_{(S,F)i} = \delta_0 + \delta_1 \sum_{(f,s)=1}^{n} \ln W_i + \delta_2 \sum_{(f,s)=1}^{n} \ln X_i + \delta_3 \sum_{(f,s)=1}^{n} \ln Y_i + \delta_4 \sum_{(f,s)=1}^{n} \ln A_i + v_{(f,s)i} \qquad (2)$$

$$\ln TC_{(S,F)i} = \delta_0 + \delta_1 \sum_{(f,s)=1}^{n} \ln W_i + \delta_2 \sum_{(f,s)=1}^{n} \ln X_i + \delta_3 \sum_{(f,s)=1}^{n} \ln Y_i + \delta_4 \sum_{(f,s)=1}^{n} \ln A_i + \delta_5 \sum_{(f,s)=1}^{n} \ln(WA)_{i(s,f)} +$$

$$\delta_6 \sum_{(f,s)=1}^{n} \ln(XA)_{i(s,f)} + \delta_7 \sum_{(f,s)=1}^{n} \ln(YA)_{i(s,f)} + v_{i(f,s)} \qquad (3)$$

Where;
$\ln TC_{(s,f)i}$ = The total cost of sugarcane and maize crop production
$W_i = (L_{fi} + L_{si})$ = The sum of costs of labour used in maize production and in sugarcane production;
$X_i = (K_{fi} + K_{si})$ =The sum of cost of capital used in maize production and in sugarcane production;
$Y_i = (D_{fi} + D_{si})$ = The sum of cost of land used maize production and in sugarcane production
$L_{fi}; K_{fi}; D_{fi}$ = The cost of labour, cost of capital and cost of land on maize production;
$L_{si}; K_{si}; D_{si}$ = The cost of labour, cost of capital and cost of land on sugarcane production;
A = Cost of information adoption;
$(WA)_i$ = The cost of labour times the cost of information adoption used in sugarcane and maize production
$(XA)_i$ = The cost of capital times the cost of information adoption used in sugarcane and maize production;
$(YA)_i$ = The cost of land times the cost of information adoption used in sugarcane and maize production.
fi = Individual maize crop farming agribusiness;
si = Individual sugarcane farming agribusiness.

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$fi + si$ = Mixed farming agribusiness.

In the 2nd phase, the effect of cost of 'utilization' only was introduced into equation (1) thereby transforming it into a functional relationship as depicted by equation (4) below:

$$\ln TC_{(S,F)} = \delta_0 + \delta_{1i} \sum_{(f,s)=1}^{n} \ln W_i + \delta_{2i} \sum_{(f,s)=1}^{n} \ln X_i + \delta_{3i} \sum_{(f,s)=1}^{n} \ln Y_i + \delta_{4i} \sum_{(f,s)=1}^{n} \ln U_i + \mu_{(f,s)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

By injecting the cost of information as a mediator in Equation 4, the new functional relationship was given by Equation 5.

$$\ln TC_{(S,F)i} = \delta_0 + \delta_{1i} \sum_{(f,s)=1}^{n} \ln W_i + \delta_{2i} \sum_{(f,s)=1}^{n} \ln X_i + \delta_{3i} \sum_{(f,s)=1}^{n} \ln Y_i + \delta_{4i} \sum_{(f,s)=1}^{n} \ln U_i + \delta_{5i} \sum_{(f,s)=1}^{n} \ln(WU)_{i(s,f)}) +$$

$$\delta_{6i} \sum_{(f,s)=1}^{n} \ln(XU)_{i(s,f)} + \delta_{7i} \sum_{(f,s)=1}^{n} \ln(YU)_{i(s,f)} + v_{i(f,s)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where;

$W_i = (L_{fi} + L_{si})$ = The sum of costs of labour used in maize production and in sugarcane production;

$X_i = (K_{fi} + K_{si})$ =The sum of cost of capital used in maize production and in sugarcane production;

$Y_i = (D_{fi} + D_{si})$ = The sum of cost of land used maize production and in sugarcane production

$L_{fi}; K_{fi}; D_{fi}$ = The cost of labour, cost of capital and cost of land on maize production;

$L_{si}; K_{si}; D_{si}$ = The cost of labour, cost of capital and cost of land on sugarcane production;

U = Cost of information utilization

$\ln TC_{(S,F)i}$ = The farming agribusiness' total cost of production (either as a sugarcane farming agribusiness or maize crop farming agribusiness)

$(WU)_i$ = The cost of labour times the cost of information utilization used in sugarcane and maize production

$(XU)_i$ = The cost of capital times the cost of information utilization used in sugarcane and maize production

$(YU)_i$ = The cost of land times the cost of information utilization used in sugarcane and maize production

fi = Individual maize crop farming agribusiness;

si = Individual Sugarcane farming agribusiness.

$fi + si$ = Mixed farming agribusiness

In the 3rd phase, summation of the cost of adoption and the cost of utilization was generated. Used as a combined figure, and introduced into Equation 1, the equation transformed into Equation 6 as follows:

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$$\ln TC_{i(S,F)} = \delta_0 + \delta_{1i}\sum_{(f,s)=1}^{n}\ln W_i + \delta_{2i}\sum_{(f,s)=1}^{n}\ln X_i + \delta_{3i}\sum_{(f,s)=1}^{n}\ln Y_i + \delta_{4i}\sum_{(f,s)=1}^{n}\ln(AU)_i + \delta_{5i}\sum_{(f,s)=1}^{n}\ln(WAU)_{i(s,f)}) + \delta_{6i}\sum_{(f,s)=1}^{n}\ln(XAU)_{i(s,f)} + \delta_{7i}\sum_{(f,s)=1}^{n}\ln(YAU)_{i(s,f)} + v_{i(f,s)} \ldots\ldots(6)$$

Where:

$W_i = (L_{fi} + L_{si})$ = The sum of costs of labour used in maize production and in sugarcane production;

$X_i = (K_{fi} + K_{si})$ =The sum of cost of capital used in maize production and in sugarcane production;

$Y_i = (D_{fi} + D_{si})$ = The sum of cost of land used maize production and in sugarcane production

$L_{fi}; K_{fi}; D_{fi}$ = The cost of labour, cost of capital and cost of land on maize production;

$L_{si}; K_{si}; D_{si}$ = The cost of labour, cost of capital and cost of land on sugarcane production;

$\ln TC_{(S,F)i}$ = The farming agribusinesses' total cost of production (either as a sugarcane farming agribusiness or maize crop farming agribusiness, or both)

δ_0 = The cost efficiency in production

$\delta_{1i}, \delta_{2i}, \delta_{3i}, \delta_{4i}$ = The coefficients of the main effect of labour, capital, land and information adoption on sugarcane production and maize production respectively;

$\delta_{5i}, \delta_{6i}, \delta_{7i}$ = The coefficients of the moderating effect of information adoption and utilization on the labour, capital and land constructs.

AU = The summation of the cost of information adoption and the cost of information utilization.

$(WAU)_i$ = The cost of labour times the cost of information adoption and utilization used in sugarcane and maize production

$(XAU)_i$ = The cost of capital times the cost of information adoption and utilization used in sugarcane and maize production

$(YAU)_i$ = The cost of land times the cost of information adoption and utilization used in sugarcane and maize production

fi = Individual maize crop farming agribusiness;

si = Individual Sugarcane farming agribusiness.

$fi + si$ = Mixed farming agribusiness

Results and Discussion

The constructs on the cost of adoption, cost of utilization, cost of sugarcane and cost of maize production were tested for their correlation and the results captured in Table 1.

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Table 1: Correlations Matrix of the Main Study Variables

		Total sugarcane cost	Total maize cost	Adoption cost	Utilization cost
Total sugarcane cost	P.Correl	1			
	Sig. (2-tailed)				
Total maize cost	P.Correl	.143*	1		
	Sig. (2-tailed)	.011			
Adoption cost	P.Correl	-.238**	-.025	1	
	Sig. (2-tailed)	.000	.662		
Utilization cost	P.Correl	.055	-.080	.321**	1
	Sig. (2-tailed)	.332	.156	.000	

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

In Table 1, there was a weak significant positive correlation between the cost of sugarcane production and cost of maize production (r = 0.143; p = 0.011). Similarly, there was a significant but weak negative association between cost of sugarcane production and cost of information adoption (r = -0.238; p = 0.000). However, there was an insignificant positive correlation between cost of information utilization and cost of sugarcane production. This agreed with (Chauhan & Shanthy, 2021) who also acknowledged a positive relationship. Furthermore, the cost of adoption was significant and positively correlated with the cost of information utilization (r = 0.321; p = 0.000). However, the degree of association was somewhat weak.

Effect of Cost of Information Adoption

Investigations on the role of cost of information adoption and utilization on cost of sugarcane production and on cost of maize production was conducted using a three-prong approach shown by equation (3, 5 and 6) and adopted a Stochastic Frontier Analysis (SFA). The first part of the analysis investigated the effect of cost of information adoption on the cost of maize production, cost of sugarcane production and cost of mixed production before the effect of the cost of information adoption and utilization was investigated for its moderation effect. The result showed that the cost of information adoption as an exogenous variable enters into the cost of maize production; cost of sugarcane production and on the cost of mixed production captured in Table 2.

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Table 2: Effect of Cost of Information Adoption

Panel 1: Cost of Information Adoption as a Variable in Pure Maize Crop Production				
Log likelihood =	67.0575			
lnoutputfd	Coef.	Std. Err.	z	P>|z|
Wald Chi 2(4)	4543.16			0.000
lnlandfd	.401	.029	13.92	0.000
lnlabourfd	.175	.023	7.72	0.000
lncapitalfd	.434	.016	27.10	0.000
lntcoa	-.013	.010	-1.35	0.177
Cons	1.128	.171	6.59	0.000
Panel 2: Information Adoption as a Variable in Pure Sugarcane Production				
Log likelihood =	24.4985			
lnoutputsc	Coef.	Std. Err.	z	P>|z|
Wald Chi 2(4)	8126.34			0.000
lnlandsc	.294	.034	8.65	0.000
lnlaboursc	.194	.058	3.36	0.001
lncapitalsc	.471	.034	13.73	0.000
lntcoasc	-.260	.090	-2.88	0.004
cons	4.357	1.073	4.06	0.000
Panel 3: Information Adoption as a Variable in Mixed Production				
Log likelihood =	5.8069			
lnoutputscfd	Coef.	Std. Err.	z	P>|z|
Wald Chi 2(4)	789.30			0.000
lnlandscfd	.089	.029	3.04	0.002
lnlabourscfd	.347	.027	13.06	0.000
lncapitalscfd	.529	.027	19.73	0.000
lntcoa	-.020	.019	-1.04	0.297
cons	1.829	.366	4.99	0.000

From Table 2, results indicate that the cost of information technology adoption negatively and significantly influenced the cost of sugarcane production $(\alpha_4 = -0.260; p = 0.004)$. This implies that the level of responsiveness of cost of sugarcane production to variations in the cost of information technology adoption was inelastic, negative and significant; that is, as the cost of information adoption changes by a given proportion, the cost of sugarcane production changes negatively but by less than the proportionate increase in the cost of information adoption. This is in consonance with (Singh, et al., 2019) who also discovered that there was low adoption of information technology in India consequently resulting into high cost of sugarcane production. On maize production and mixed production, the effect was insignificant.

Moderating Effect of Cost of Information Adoption

The cost of information adoption was introduced into the cost of maize, sugarcane and mixed production together with a moderator and the results summarized in Table 3.

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Volume 1, Number 1, 2023 ISSN N0 2791-190X

Table 3: Moderation Effect of Cost of Information Adoption

Panel 1: Moderation Effect of Cost of Information Adoption in Maize Production

Log likelihood = 67.0571				
lnoutputfd	Coef.	Std. Err.	z	P>|z|
Wald Chi 2(4)	4553.58			0.000
lnlandfd	.414	.029	14.33	0.000
lnlabourfd	.175	.023	7.73	0.000
lncapitalfd	.434	.016	27.13	0.000
lnlandfdtcoa	-.013	.010	-1.35	0.177
cons	1.128	.174	6.50	0.000

Panel 2: Information Adoption as a Moderator in Sugarcane Production

Log likelihood = 24.4985				
lnoutputsc	Coef.	Std. Err.	z	P>|z|
Wald Chi 2(4)	8127.18			0.000
lnlandsc	.554	.105	5.27	0.000
lnlaboursc	.194	.058	3.36	0.001
lncapitalsc	.471	.034	13.73	0.000
lnlandtcoasc	-.260	.090	-2.88	0.004
cons	4.357	1.073	4.06	0.000

Panel 3: Information Adoption as a Moderator in Mixed Production

Log likelihood = 5.8069				
lnoutputscfd	Coef.	Std. Err.	z	P>|z|
Wald Chi 2(4)	789.30			0.000
lnlandscfd	.109	.035	3.07	0.002
lnlabourscfd	.347	.027	13.06	0.000
lncapitalscfd	.529	.027	19.73	0.000
lnlandscfdtcoa	-.020	.019	-1.04	0.297
cons	1.829	.366	4.99	0.000

From Table 3, the introduction of the cost of information adoption is not significant in influencing the factors of production in either maize or mixed production but is being absorbed into the cost of land in sugarcane production. However, the coefficient on cost of land in sugarcane production is negative and significant $(\alpha_4 = -0.260; p = 0.004)$. Given this, the amplification of the cost of land affected the cost of sugarcane production negatively; that is, the level of responsiveness to sugarcane production due to variations in the moderated cost of land was inelastic, negative and significant.

This result corroborates findings by Ncoyini et al. (2022) which suggests that agricultural information adoption could be interacting with other input factors in influencing the production cost of sugarcane in South Africa, and that inaccessibility of climate information sources and lack of capacity to respond to the provided information greatly hinders also the access to and the use of climate information. In addition, introduced as a moderator into the cost of maize, sugarcane and mixed production, the moderating effect of cost of information utilization is summarized in the Table 4.

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Table 4: Moderating Effect of Cost of Information Utilization on the Cost of Maize, Sugarcane and Mixed Production

Panel 1: Cost of Information Utilization as a Moderator in Maize Production				
Log likelihood =	67.2009			
lnoutputfd	Coef.	Std. Err.	z	P>|z|
Wald Chi 2(4)	4575.28			0.000
lnlandfd	.420	.030	14.20	0.000
lnlabourfd	.172	.022	7.70	0.000
lncapitalfd	.435	.016	27.20	0.000
lnlandfdtcou	-.015	.010	-1.46	0.144
cons	1.116	.169	6.59	0.000
Panel 2: Cost of Information Utilization as a Moderator in Sugarcane Production				
Log likelihood =	21.4247			
lnoutputsc	Coef.	Std. Err.	z	P>|z|
Wald Chi 2(4)	4863.43		0.000	
lnlandsc	.265	.042	6.26	0.000
lnlaboursc	.310	.054	5.78	0.000
lncapitalsc	.404	.032	12.48	0.000
lnlandtcousc	.006	.015	0.42	0.677
cons	1.250	.259	4.83	0.000
Panel 3: Cost of Information Utilization as a Variable in Mixed Production				
Log likelihood =	5.7055			
lnoutputscfd	Coef.	Std. Err.	z	P>|z|
Wald	787.05			0.000
lnlandscfd	.106	.035	3.03	0.002
lnlabourscfd	.342	.026	13.02	0.000
lncapitalscfd	.532	.027	19.82	0.000
lnlandscfdtcou	-.018	.019	-0.93	0.350
cons	1.803	.364	4.95	0.000

From Table 4, results indicate that the cost of information utilization neither moderates the cost of input factors in maize and sugarcane nor mixed production.

Moderating Effect of Cost of Adoption and Cost of Utilization on Cost of Maize, Sugarcane and Mixed Production

The results upon the introduction of the cost of information adoption and cost of utilization as a moderator into the cost of maize, sugarcane and mixed production are summarized in the Table 5.

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Table 5: Moderating Effect of Cost of Adoption and Cost of Utilization on Cost of Maize, Sugarcane and Mixed Production

Panel 1: Moderating Effect of Cost of Utilization and Adoption on Maize Production				
Log likelihood =	67.4728			
lnoutputfd	Coef.	Std. Err.	z	P>|z|
Wald Chi 2(4)	4603.30			0.000
lnlandfd	.420	.029	14.26	0.000
lnlabourfd	.175	.023	7.75	0.000
lncapitalfd	.435	.016	27.29	0.000
lnlandfdtcou	-.011	.012	-0.91	0.360
lnlandfdtcoa	-.008	.011	-0.74	0.460
cons	1.158	.173	6.68	0.000
Panel 2: Moderating Effect of Cost of Adoption and Utilization on Sugarcane Production				
Log likelihood =	36.0084			
lnoutputsc	Coef.	Std. Err.	z	P>|z|
Wald Chi 2(4)	22153.70			0.000
lnlandsc	.386	.064	6.00	0.000
lnlaboursc	.280	.023	11.97	0.000
lncapitalsc	.377	.019	20.26	0.000
landtcousc	-5.51e-10	2.37e-10	-2.33	0.020
labourtcousc	8.66e-11	1.92e-10	0.45	0.653
capitaltcousc	5.45e-10	8.24e-11	6.62	0.000
lnlandtcoasc	-.088	.067	-1.32	0.187
cons	2.536355	.777	3.27	0.001
Panel 3: Moderation Effect of Cost of Adoption and Utilization on Mixed Production				
Log likelihood =	5.9627			
lnoutputscfd	Coef.	Std. Err.	z	P>|z|
Wald Chi 2(4)	788.80			0.000
lnlandscfd	.101	.036	2.81	0.005
lnlabourscfd	.345	.027	12.95	0.000
lncapitalscfd	.545	.033	16.72	0.000
lncapitalscfdtcoa	-.015	.021	-0.72	0.472
lnlandscfdtcou	-.012	.021	-0.56	0.577
cons	1.874	.376	4.99	0.000

From Table 5, the effect of cost of information adoption as a moderator was not significant in influencing the factors of production in either maize or mixed production but was being absorbed into the cost of land in sugarcane production.

Conclusion and Recommendation

On one hand, this study has found that the cost of information adoption negatively and significantly moderates the cost of land in sugarcane production. On the other hand, the cost of information utilization has no statistically significant effect on the input factors in maize, sugarcane or mixed production. When combined together, the total cost of information adoption and utilization has no

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statistically significant effect on the factor inputs in maize, sugarcane or mixed production. This study, therefore, concludes that the cost of information adoption only acts to curtail the resources meant to acquire more land for sugarcane production. Even so, farming agribusinesses still undermine the kind and amount of information they can get through the various information gadgets, explaining the lethargy in their use.

It can, therefore, be concluded that information adoption, as opposed to information utilization, had a statistically significant effect on the cost of land in sugarcane production in the study area. Since the adoption of information is usually hampered by a lack of logistics, downscaled information, and confidence; capacity-building of the farming agribusinesses must be mainstreamed in order to promote efficient adoption and strengthening of information services for use by farming agribusinesses in the study area. Therefore, a lot of physical extension services and advocacy on use of technology to acquire agricultural information is required within the Nyanza region, if agricultural output is to be increased and input costs minimized.

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