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Interaction Effects of Agricultural Output Price and Agricultural Productivity on Industrialization in Sub-Saharan Africa

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Abstract. This study explores the interactive role of agricultural output price in the agricultural productivity and industrial output nexus. The data used are on sub-Saharan African countries as listed in the World Bank database of the World Development Indicators and Food and Agriculture Organization from 1995 to 2022. The results from the system-generalized method of moments estimation demonstrate that the agricultural output price increases the effect of agricultural productivity on industrial output. This result then shows that with a better agricultural output price, there will be a significant positive effect of agricultural productivity on the industrial output in sub-Saharan Africa. Thus, the study advocates the adoption of a counterbalanced agricultural output price policy in the form of subsidy through minimum price guarantee and government direct purchase to make the price stable and attractive for the teeming population and investors while also ensuring the affordability of the output for consumers across all income groups in the region.

Keywords: agricultural output price, industrialization, interaction effect, sub-Saharan Africa, system-generalized method of moments

JEL Classification: Q10, Q11, L60, C23

1. Introduction

The economies of many developing countries, including sub-Saharan Africa (SSA), are characterized by an unprecedented drift of workers out of the primary-agrarian sector to industry and services, with services receiving the larger share. This low share of industry in employment compared to services (referred to as de-industrial productivity) in SSA has culminated in a decline in agricultural produce, the range of agricultural produce, and its volume of exports (Rodrik, 2016).

Data published by *Africa's Pulse*, a World Bank Group, in 2019 on the structural transformation in SSA revealed that the service sectors with a lower share of employment compared to the agricultural sector has the highest value added in terms of productivity, while agriculture with the highest share of employment has the least value added. Meanwhile, the proportion of industry in total employment and value added is the lowest among the three sectors (World Bank, 2019). Consequently, industrial productivity in the region has been weak and uneven (World Bank, 2021). Thus, features of de-industrialization, such as declining output, rising input costs, and dearth of factories, prevail across most economies in SSA. This has positioned the region's ranking as one of the least in the share of global manufacturing (United Nations Industrial Development Organization, 2020).

The debate in the literature is whether lowering agricultural output price can help extract surplus from agriculture for rapid industrialization (Fardmanesh, 2017; Tomek and Kaiser, 2014). Meanwhile, low pricing of agricultural products in the market creates favourable price incentive for manufactured goods at the expense of agricultural products (Tomek and Kaiser, 2014). This disparity in output price between the two sectors has been attributed as the core reason for the sectoral disparity in productivity and the resultant decline in the role of agricultural sector in favour of the industrial sector (Dastagiri and Bhavigna, 2019). Since there is linkage and interdependence between agriculture and industry via the supply of raw materials and food from the agricultural sector to the industry and, in return, the provision of manufactured and agro-allied products by industry for agricultural use, changes in agricultural prices will have effect on industrial growth (Guda, Dawande, Janakiraman, and Rajapakshe, 2021).

According to Rattso and Torvik, (2003), the price of agricultural products negatively affects output in the sector, while the output is positively related to the price in industry due to nominal wage response (Xie and Wang, 2017).Thus, government intervention in the agricultural sector, particularly in developing countries, through the use of incentive policies – specifically output price support – is expected to have implications for the dynamics of agricultural production and subsequently industrialization in economies undergoing rapid transitions. This price support involves government intervention to maintain minimum prices for agricultural commodities, ensuring profitability for farmers (Lin and Huang, 2021; Guda, Dawande, Janakiraman, and Rajapakshe, 2021). Among numerous agricultural support incentives, the output price support, or subsidy, offers more beneficial effects in enhancing the total income of farmers (Tang, Wang, and Zhao, 2023).

In the extant literature, there is a paucity of studies on the interaction effects of agricultural output price on industrial output in sub-Saharan Africa (Mendes, Bertella, and Teixeira, 2014). The few available evidence not only covered a limited number of SSA countries with conclusions that may not apply to all the countries in the region (Rodrik, 2016; Nguimkeu and Zeufack, 2019) but also ignored the important interactive role of agricultural output price in analysing industrial productivity. Also, while some studies provide evidence of de-industrial productivity in SSA, several other studies argue that it is too early to submit that the region's industrial productivity potential can no longer be realized (Kruse, Mensah, Sen, and Vries, 2021). This study aims to offer an additional insight into the literature based on the inconclusive evidence of existing studies on the effect of agricultural productivity on industrial productivity. This study addresses this lacuna by examining how agricultural output price through its interaction with agricultural productivity impact industrial output in sub-Saharan Africa.

This study investigates the interaction effect of agricultural output price and agricultural productivity on industrialization in sub-Saharan Africa. The specific objectives of the study are to investigate the effect of agricultural output price on industrialization, determine the effect of agricultural productivity on industrialization, and examine the interaction effect of agricultural output price and agricultural productivity on industrialization in sub-Saharan Africa.

This study contributes to the literature by demonstrating with the use of empirical literature and statistical data the intricate relationship between agricultural productivity, industrial output, and agricultural output prices in SSA. Thus, the study provides a more comprehensive understanding of economic development in SSA and underscores the importance of the competitiveness in the agricultural sector and strategic agricultural output pricing for broader economic development. The study also offers empirical support for the idea that adjusting output prices can lead to a reallocation of resources from agriculture to industry, fostering industrial growth.

This empirical analysis sheds light to the forces that power agricultural labour exits and the reasons why the agricultural sector remains the largest employer of labour and why the income of rural dwellers, who are predominantly farmers, remains so low. The analysis of the effect of agricultural output price will help policy makers in introducing attractive pricing policies with a view to stabilizing prices of agricultural output and ensuring an adequate production and supply of food. The study would inform policies capable of enhancing the welfare of the general consumers through improved access to locally made manufactured products and food supply that can be well compared to international market prices through an effective pricing redistributive policy. This research will promote awareness and serve as a source of valuable information for future analysis of agricultural output prices in sub-Saharan Africa in the field of development economics, especially industrial economics and agricultural economics as well as microeconomics.

The rest of the study is organized as follows. Section 2 presents a literature review followed by Section 3 on methodology. In Section 4, the focus is on results and discussion, while in Section 5 the conclusions and recommendations are presented.

2. Literature Review

Industrialization can be conceptualized as a social and economic process that brings about a transformation of the society from a traditionally purely agrarian economy into a modern advanced and more socialized economy. Industrialization is the prominence of a process involving a range of industrial plants opened by several entrepreneurs over a slower timescale in local economies and changing the outlook of regional economy (Simandan, 2009). Although industrialization can occur for a variety of causes – because it has no single cause –, its consequences vary widely across geographical regions and historical times. The English Industrial Revolution took into account factors that have been ignored hitherto such as genetic changes and urbanization, while for all other cases of industrialization the imitation factors that contributed to the process of industrialization are capitalism and modernization.

On the other end, agriculture is sometimes limited to only the cultivation of crops, with animal domestication excluded, but it generally covers both (Harris and Fuller, 2014). The price of agricultural output is, in theory, the price one pays for that item at their farm gate or village site (Chandrasekhar, 2013). Agricultural product prices are significantly more volatile than other non-farm products and services (Fitria, Harianto, Priyarsono, and Achsani, 2019). Consequently, a change in the expected price of the farmers will lead to a relatively lower change in supply in the shorter term or in the long run; as such, price is inelastic. Despite the fact that agricultural product prices are more volatile than many other prices, the average of a group of prices (indexes) is less volatile. This is known as the fixed-flex model (Andrews and Rausser 1986).

Output price support involves government intervention to maintain minimum prices for agricultural commodities, ensuring profitability for farmers (Lin and Huang, 2021). According to Guda, Dawande, Janakiraman, and Rajapakshe (2021), output price support represents the minimum price at which the government commits to purchasing a unit of a particular crop from farmers. The determination of this price involves considerations of production costs, demand–supply dynamics, and the need to incentivize farmers.

Several theories abound: the Kaldor model of manufacturing sector and three-sector hypothesis, circular cumulative causation theory by Myrdal. The Kaldor (1967) model of manufacturing sector and economic development is relevant to this study because the model based on the experience of Western Europe explains that agricultural modernization is a precondition to achieving a continuous rise in industrial output. That is, industrial productivity is determined by growth in agricultural modernization, which provides the source of food supply and labour that is needed in the non-agricultural sector. Furthermore, the model believed that as the industrial sector progresses, growth in productivity in other sectors, including agriculture, the service sectors, and the economy at large, will increase via the positive spillover effect in the form of technological advancement and complementary markets in the service sector. The three-sector hypothesis of structural shifts is relevant to this study because it has separated economy into two categories: the technological advancing segment and the non-progressive unit. These units are differentiated, as the progressive sector uses more technology, while the non-progressive uses more labour. As such, cost disease affects the non-progressive sector more because wage rate and output growth are higher in the progressive sector, which is the industrial sector. Thus, output and price are consequently favourable in the sector compared to agriculture.

In the literature, most previous studies on agricultural productivity and industrial productivity linkage concentrated on one particular side of the coin. While some of the studies focused their attention on the effect of agricultural productivity on industrial productivity, evidence also abounds in studies focused on the reverse side of the issue. Although there are sparse studies on the role of agricultural support incentives in agricultural productivity, the role of agricultural output price has been largely ignored in the analysis of the linkage relationship between the two sectors.

On the linkage between agricultural productivity and industrial productivity, Subramaniam and Reed's (2009) study employed a Vector Error Correction Modelling to examine the connections between various sectors, namely agriculture, manufacturing, service, and trade in Poland and Romania. They found that these sectors in both countries exhibited similar patterns over the course of the study, indicating interdependency in their growth rates. Notably, a long-term relationship was established between industry, services, and trade and trade sectors and agriculture. In Poland, the industrial sector had a positive impact on agriculture, while the service sector showed mixed results. In Romania, the industrial sector had an adverse effect on agriculture, but the service sector made a positive contribution. Short-term results indicated that the service sector played a significant role in the Polish economy, positively affecting other sectors, while the industrial sector had a negative impact. A similar pattern was observed in the Romanian economy, although the results were not statistically significant. As expected, the role of agriculture in the short run was not significant in its impact on other sectors, except for a direct influence on industry in Romania.

Using a system of simultaneous equations, Onakoya (2013) explored the relationships between services, oil and gas, the manufacturing and agricultural sectors. The study revealed that the intersectoral relationships are complex and bidirectional. Interactions and linkages between sectors generated externalities and spillover effects. Furthermore, the study found that the role of agriculture was unidirectional, with capital mainly flowing towards oil and gas, tertiary services and industry. Interactions between sectors were sometimes detrimental. Waniko (2016) empirically investigated the causal nexus between agricultural sector components and other sectors in Nigeria's economy, using vector error correction and data spanning from 1981 to 2012. The research found that agriculture and industry have a causal relationship in the long run.

Shifting the focus towards agricultural support incentives and their impact on agricultural productivity, Su, Heerink, Oosterveer Tan, and Feng (2021) conducted a research to investigate the effects of the Minimum Grain Procurement Price Programme on households' use of chemical fertilizers and pesticides. Their study utilized panel data regression techniques and found that the programme had a negative effect on chemical fertilizer and pesticide use. While higher grain prices resulting from the programme increased agrochemical use, the study identified counteracting effects, as the programme further inspired areas for expansion, resulting in the use of lesser agrochemical per unit of land. The direct negative effect of the procurement price of rice on fertilizer and pesticide use was found to be significant.

In a similar vein, Lin and Huang (2021) conducted an empirical analysis to determine how government policies in agriculture affect land rental prices. They looked at three main policies: agricultural tax, agricultural subsidy, and output price support. Their findings showed that when the government removed agricultural tax on cultivated land and introduced price support policies, land rental prices went up significantly. However, the impact of agricultural subsidies given to contract holders or owners on land rental prices was not significant. Another study by Tang, Wang, and Zhao (2023) explored the effects of input and output farm subsidies on farmer welfare, income inequality, and consumer surplus. Using a game-theoretical model, they found that both subsidy types reduced overall income inequality, but they had different effects. The input subsidy decreased income inequality among farmers, while the output subsidy increased it. Farmers with low yields preferred the input subsidy, while those with high yields favoured the output subsidy. Overall, the output subsidy was more effective in increasing total farmer income, while the input subsidy was better at reducing income disparities and improving consumer surplus.

Also, von Cramon-Taubadel and Goodwin (2021) employ a comprehensive review of new advancement in the transmission of price in the market of agricultural products, focusing on spatial and vertical linkages. The methodological approach involves the use of increasingly nonlinear time-series models to understand spatial market linkages. The study finds that spatial market integration is a crucial aspect of agricultural markets, influencing the relationships between prices in different geographical locations. Adeeth Cariappa, Acharya, Adhav, Sendhil, and Ramasundaram (2022) investigate the effects of the 2019 coronavirus lockdown on the price of agricultural commodity and consumer behaviour in India. The study employs time series approach based on data collected from seven hundred and twenty-nine consumers and two hundred and twenty-five farmers and a synthesis of literature on food loss and waste. The findings highlight significant price increases for certain commodities post-lockdown, consumer behaviour shifts, and disruptions in farmers' ability to dispose of produce. Despite panic purchases leading to initial food wastage, the study emphasizes the resilience of the Indian agriculture.

3. Methodology

The ex post facto research design was applied in this study. The research design was deemed appropriate because the main goal of this analysis is to explore the nexus and explain why and how the independent variables best predict variations in the dependent variable based on the use of empirical data.

In order to investigate the interaction effect of agricultural output price and agricultural productivity on industrial output in sub-Saharan Africa, this study adapted the model used in the study conducted by Dholakia and Sapre (2013), where they used two dynamic regression equations to estimate the responsiveness of the growth of agricultural and total output to changes in relative output prices. As a modification to the model, since the present objective is the interaction effect of agricultural output price and agricultural productivity on industrial output, a single dynamic equation was employed as follows:

$$Y_{I_{it}} = \alpha Y_{I_{it-1}} + \beta Y_{A_{it}} + \rho P_{A_{it}} + \delta P_{A_{it}} \times Y_{A_{it}} + \sum_{j=1}^{J} \gamma_j Z_{jit} + \theta_i + \varepsilon_{it},$$

where i, the cross-sectional identifier, stands for ith country and t, the time identifier, for the ^{ith} year; θ_i is the country-specific fixed effect, $Y_{I_{it-1}}$ is the lagged value of $Y_{I_{it}}$ of country i at time t, $Y_{I_{it}}$ is the industrial productivity proxy by the industrial value added of country i at time t, $Y_{A_{it}}$ is agricultural productivity of country i at time t, $P_{A_{it}}$ is the price of agricultural output of country i at time t, $P_{A_{it}} \times Y_{A_{it}}$ is the interaction term of country i at time t, and Z is a vector of control variables (Gujarati, 2004; Asiedu, 2013). The data is on forty-eight (48) cross-sectional units (i) over the period of twenty-eight (28) years from 1995 to 2022 (t).

The data employed in this study covers forty-eight (48) sub-Saharan Africa (SSA) countries as listed in the World Bank 2022 data on sub-Saharan Africa (World Bank, 2022). Twelve (12) countries comprising Comoros, Congo, Dem. Rep., Eswatini, Gabon, Lesotho, Liberia, Mauritania and Sao Tome, Uganda, Sudan, South Sudan, Somalia, and Principe were excluded from the analysis due to unavailability of data on agricultural output price and capital employed in agriculture for the selected years. Consequently, the number of countries used in the region of sub-Saharan Africa is 36. The selection of sub-Saharan Africa as the focus of this study stems from the disparities in the distribution of benefits of the transition process among countries in this region. Some countries have achieved more success in this transition compared to others, as highlighted by Subramaniam and Reed in 2009. Furthermore, the transition process in sub-Saharan Africa is notably slower compared to other developing regions. Many of these countries continue to have a significant portion of their workforce employed in the agricultural sector, which distinguishes them from industrialized countries, as noted by the World Bank in 2019.

The data used in this study was sourced from the World Bank's World Development Indicator and the Food and Agricultural Organization. The dataset spans a period of 28 years, covering the years from 1995 to 2022. This extended timeframe allows us to build upon the analysis of structural transformation in SSA presented by the World Bank in 2019. Specifically, it offers insights into the patterns of structural transformation in the region, particularly in terms of the movement of labour from one sector to another. For more detailed information about the data sources and units of measurement, refer to *Table 1*.

Table 1. *Variable description and sources of data*

SN	Variables	Description Symbol	Operational Definition	Sources
1	Agricultural productivity	$Y_{A_{it}}$	Agriculture, value added	World Development Indicators (2022)
2	Industrial productivity	$Y_{I_{it}}$	Industry, value added	World Development Indicators (2022)
3	Agricultural output price	$P_{A_{it}}$	Agriculture producer price index	Food and Agricultural Organization (2022)

Source: authors' compilation (2023)

Theoretically, a positive or negative relationship is expected between agricultural output price and agricultural productivity in the economy because agricultural output price, being the price faced by producers, reflects the incentives for production and investment. When the relationship is negative, it implies that agricultural output price provides no or less incentive to produce more output, and when it is positive, the price provides incentives for production. The lagged value of agricultural productivity is also expected to have a positive relationship with agricultural productivity. The interaction term is expected to have a negative effect on industrial productivity because it measures the farmers' total income for any productive time period, and as such a rise in farmers' income will raise current production, thereby shifting resources against industry, but a decline in farmers' income is expected to shift resources in favour of industry.

By its very nature, this study involves the analysis of panel data because it aims to analyse movement over the time of subjects across successive states, countries, or conditions. In the analysis, the study applies three procedures consisting of the pre-estimation, estimation, and post-estimation of the model. In pre-estimation, the study uses the normality test (Jarque–Bera), the test for multicorrelation (correlation matrix), the unit root test (Levin, Lin, and Chu (2002), Augmented Dickey–Fuller and Phillips–Perron tests proposed by Maddala and Wu (1999) and Choi (2001)), and the panel cointegration test (Pedroni's (1999) methodology). Both the system GMM estimator proposed by Blundell and Bond (1998) and Konya (2006) and the causality test will be employed in the actual estimation, while the tests for serial correlation, validity of instruments and OLS and within group (fixed effects) tests will be used for the post-estimation.

The system-generalized method of moments (GMM) estimator proposed by Blundell and Bond (1998) will be used to analyse models one, two, and three because it makes use of more instruments compared to differenced GMM and provides a more efficient estimator through the use of additional moment conditions to offset the poor instruments problem. It is also less biased than the difference GMM estimator because it is a weighted sum of the difference and the level estimator, and these biases move in opposite directions (Gujarati, 2004; Hayakawa, 2007).

4. Results and Discussion

The estimation approach employed in the study was informed on the basis of the preliminary tests that were undertaken to help attain this aim of the study. To check the accuracy of the estimates, post-estimation tests using the Wald test, normality test, and Arellano–Bond Serial (ABS) correlation test were also conducted.

4.1. Preliminary Analysis

This preliminary analysis, which includes a descriptive analysis, a multicollinearity test, and a unit root test, is presented in *tables 2, 3*, and *5*.

As can be observed by the higher-than-one ratio between the standard deviation and mean of the variables, the descriptive statistics summary in *Table 2* reveals that YI, YA, and PA values varied significantly over time and between countries. As a result, it is possible that the distribution of the variables across nations and times is neither symmetrical nor bell-shaped. In other words, the Jarque–Bera statistics will be near zero. The significant level of variability in the dataset is confirmed by the high standard deviation of the variables: 7.79, 0.86, and 0.89 for YI, PA, and YA respectively. Because of the heterogeneity properties implied by the standard deviation, the appropriateness of the SGMM dynamic panel approach is justified.

Table 2. *Descriptive statistics*

	YI	PA	YA
Mean	0.353	0.089	0.122
Median	0.057	0.045	0.049
Maximum	230.514	20.892	18.144
Minimum	-0.998	-0.999	-0.994
Std. Dev.	7.788	0.858	0.893
Skewness	29.376	19.305	14.324
Kurtosis	868.439	438.996	253.476
Jarque–Bera	27589306	6721398	23781.2
Probability	0.000	0.000	0.0000
Observation	880	842	898

Source: authors' compilation (2023)

Notes: YA: agricultural productivity; PA: agricultural output price. The variables remain as defined in *Table 1* in Section 3.

Despite the region's abundant agricultural resources, the average agricultural productivity (YA) value, which is 12%, is low. Additionally, the mean is skewed towards the minimum value (Min. = -0.9943; Mean = 0.1215; Max. = 18.1435), indicating that agricultural output across the time period and nations is often poor.

The average agricultural output price (PA), which is 9%, is likewise quite low. Meanwhile, the low agricultural output price will have an impact on total harvest, yields, or production in future periods, making the sector less desirable for capital investment and employment, which will then have a negative impact on the supply of raw materials to industry. Another indication of the low value of agricultural production price across nations and time periods is the fact that the mean tends towards the minimum value (Min. = -0.9995; Mean = 0.0892; Max. = 20.8920).

Due to the fact that their means are higher than the median, YI, YA, and PA have a long right tail (i.e. positively skew). Additionally, these variables exhibit kurtosis values larger than three, indicating leptokurtic behaviour. The probability value of the Jarque–Bera statistics for the variables YI, YA, and PA is less than the crucial value of 0.05. This indicates that these variables do not follow a normal distribution.

Given the linear nature of the link between the variables in the model, it was determined that the Pearson's correlation technique was appropriate for this investigation (i.e. continuous-level variables). The findings of the correlation analysis are reported in *Table 3* below.

Table 3. *Correlation matrix*

	YI	PA	YA
YI	1.000		
PA	-0.029	1.000	
YA	0.092	-0.092	1.000

Source: authors' compilation (2023)

Notes: YA: agricultural productivity; PA: agricultural output price; YI: capital employed in agriculture.

The correlation coefficient between YI and YA shows a positive sign, as demonstrated in *Table 3*. This shows that there is a positive correlation between industrial output and agricultural productivity. These facts suggest that as agricultural productivity increases, so will industrial output and vice versa.

Contrary to expectations, the YI and PA and the YA and PA correlation coefficients are negative. This finding indicates that agricultural output price has an inverse relationship with agricultural productivity and industrial output. The negative correlation between industrial output and agricultural output prices in SSA indicates that the negative association between agricultural output price and agricultural productivity lead to a negative association with industrial output. That is, an adverse association between agricultural output price and agricultural productivity will also lead to a negative association between agricultural output price and industrial output.

Table 4. *Lag selection*

		LR	FPE	AIC	SC	HQ
0	-2033.435	NA	0.649	8.081	8.106	8.091
1	-1675.968	709.260	0.163	6.698	6.799	6.738
2	-1631.840	87.031	0.142	6.559	6.735	6.628
3	-1624.626	14.141	0.143	6.566	6.817	6.665
4	-1620.002	9.010	0.145	6.583	6.910	6.712
5	-1617.695	4.466	0.149	6.609	7.012	6.768
6	-1611.486	11.951	0.151	6.621	7.099	6.808
7	-1606.378	9.770	0.153	6.636	7.189	6.853
8	-1604.119	4.293	0.157	6.663	7.292	6.909

Source: authors' compilation (2023)

Notes: * indicates the lag order selected by the criterion; LR: sequential modified LR test statistics; FPE: Final Prediction Error; AIC: Akaike Information Criterion; HQ: Hanan-Quinn Information.

Since the use of a simple correlation coefficient in the case of two explanatory variables of 0.8 as a rule of thumb to detect multicollinearity can lead to misleading results, detecting multicollinearity even where it does not exist, the study focuses primarily on whether or not there is a perfect collinearity (Gujarati and Poter, 2009;

Wooldridge, 2010). Since no pair of variables displays complete collinearity and the correlation coefficients are less than 0.8, there is no tendency for the estimates to be skewed. *Table 4* displays the outcome of the lag order selection criterion.

According to the results provided in *Table 4*, the maximum number of two (2) lags that met the requirements of the LR, FPE, AIC, and HQ criteria was shown to be adequate.

For robustness, three (3) panel data unit root tests were used: Levine, Lin, and Chu-LLC (2002), Augmented Dickey–Fuller Fisher (ADF-Fisher), and Phillips–Perron Fisher (PP-Fisher). No trend and intercept, intercept simply, and trend and intercept were all given in the specification. The individual nation heterogeneity (individual unit root) and the individual country common or homogeneous aspects are both addressed by built-in methods in both tests. *Table 5* presents this finding.

Table 5. *Panel unit root*

Spec.	Vari-ables	LLC-t statistics		ADF-Fisher chi-square		PP-Fisher chi-square		Order
		Level	First Diff.	Level	First Diff.	Level	First Diff.	
No trend and intercept	YI	-18.421*** (0.000)	-36.073*** (0.000)	424.948*** (0.000)	834.989*** (0.000)	3.7409 (0.000)	817.533 (0.000)	I(0)
	YA	4.301 (1.000)	-5.381*** (0.000)	17.772 (1.000)	70.528 (0.329)	13.189 (1.000)	610.172*** (0.000)	I(1)
	PA	3.504 (0.999)	-5.022*** (0.000)	27.527 (0.999)	55.410 (0.497)	23.005 (1.000)	734.984*** (0.000)	I(1)
With intercept only	YI	198.042 (1.000)	154.572 (1.000)	330.667*** (0.000)	639.551*** (0.000)	946.216 (0.000)	1032.660*** (0.000)	I(0)
	YA	-3.214*** (0.001)	29.290 (1.000)	64.727 (0.521)	48.470 (0.948)	29.351 (1.000)	476.034*** (0.000)	I(0)/I(1)
	PA	-1.819** (0.035)	20.731 (1.000)	38.913 (0.960)	50.706 (0.675)	49.015 (0.983)	638.028*** (0.000)	I(1)
With intercept and trend	YI	222.150 (1.0000)	174.07 (1.000)	256.532*** (0.000)	628.454*** (0.000)	3380.580*** (0.000)	6561.58*** (0.000)	I(0)
	YA	32.714 (1.0000)	46.532 (1.000)	31.7220 (0.999)	33.395 (0.997)	80.840 (0.223)	356.127*** (0.000)	I(1)
	PA	22.171 (1.000)	30.118 (1.000)	38.461 (0.965)	55.864 (0.480)	100.802** (0.014)	949.022*** (0.000)	I(0)

Source: authors' compilation (2023)

Notes: ***, **, and * denote significance at 0.01, 0.05, and 0.10 critical values respectively. YI: industrial output; YA: agricultural productivity; PA: agricultural output price.

According to the findings presented in *Table 5*, agricultural productivity (YA) and agricultural output price (PA) are stationary at first difference, while industrial output is stationary at level based on the three panel unit root tests and the specifications used.

4.2. Empirical Results

System-generalized method of moments (SGMM) is used to estimate the model to determine the interaction effect of agricultural output price and agricultural productivity on industrial output. The outcome produces a GMM-type instrument based on Arellano and Bond (1991) that solely uses internal instruments based on the lag one of all exogenous variables as the standard instrument. *Table 6* reports the outcome.

Table 6. *Dynamic system GMM estimates*

Variables	**Dependent variable: Agricultural productivity (YA)**			
	Coefficient	**Std. Error**	**t-statistics**	**Probability**
Lag of industrial output $Y_{I_{it-1}}$	-0.007***	0.001	-4.808	0.000
Agricultural output price $P_{A_{it}}$	0.001***	1.691	-87.409	0.000
Interaction of agricultural output price and agricultural productivity $P_{A_{it}} * Y_{A_{it}}$	0.002***	2.480	83.246	0.000
F-test of joint significance	F = 2.6411			
Arellano bond for AR(1) in first difference	Z = -2.106**, pr < z = 0.035			
Arellano bond for AR(2) in first difference	Z = -0.699, pr < z = 0.484			
Hansen J-test of overriding restrictions	Pr > chi(2) = 0.497			
Number of instrument	36			
Number of countries	36			
Number of observations	702			

Source: authors' compilation (2023)

Notes: ***, **, and * denote significance at 0.01, 0.05, and 0.10 critical values respectively.

In the results summarized in *Table 6*, although both the lag of industrial output and that of agricultural output price proved to be significant in the model, the main consideration is on the coefficient of the interaction between agricultural output price and agricultural productivity. The interaction effect of agricultural output price on the relationship between agricultural productivity and industrial output can be stated as follows:

$$\frac{\Delta YI}{\Delta YA} = \beta_1 + \beta_2 \overline{P_A},$$

where β_1 is the coefficient of PA, β_2 is the coefficient of the interactive term (i.e. the coefficient of PA*YA), while $\overline{P_A}$ is the mean value of PA displayed in *Table 6*. The result of the computation is given as:

$$\frac{\Delta YI}{\Delta YA} = 0.001 + 0.002(0.0892) = 0.003.$$

This shows that, on the average, with agricultural output price, a percentage increase in agricultural productivity would increase industrial output by 0.0003 percentage points. This implies that agricultural output price increases the effect of agricultural productivity on industrial output. This then shows that with a better agricultural output price, there will be a significant positive impact on industrial output, as the positive effect of the variable on its own on agricultural productivity is capable of promoting industrialization. This result is particularly interesting, as it provides credence to the key argument in this study that the price factor, especially agricultural output price, is capable not only of enhancing productivity in agriculture but also of achieving industrialization, especially in developing countries like SSA, which are at the early stages of development and are predominantly mono-product economies exporting only primary commodities, with agricultural product constituting the bulk of such exports. The result conforms to Preobrazhensky's (1926) first premise (P1) that a price policy in the form of a lower output price, which forced a reallocation of resources from agriculture to industry, will necessarily promote industrialization and subsequently raise national income in the short term and promote growth in the longer term. Nonetheless, such policies in the view of Martin and Warr (1990) may also impoverish the rural population and frequently lead to food shortages.

Table 6 also shows that the number of the model's instrument, which is thirty-six (36), is less than the number of observations, which is seven hundred and two (702). As a result, the estimates are free of the issue of instrument proliferation, which may lead to the overfitting of endogenous variables and may reduce the effectiveness of Hansen's test to determine the validity of the instruments (Roodman, 2009). Also, the AR(2) coefficients (Z = -0.6999, pr < z = 0.4839) are not statistically significant at the 5% level; there is no evidence of second-order auto-correlation in the model specification. Finally, *Table 6* shows that the instrument sets are not overidentified according to Hansen's statistics (Pr > chi(2) = 0.4966), which is not statistically significant at the 5% level.

5. Conclusions and Recommendations

The results of the SGGM estimation for the interactive role of agriculture output price in the agricultural productivity and industrial output nexus demonstrates that a percentage increase in agricultural productivity would increase industrial output by 0.0003 percentage points. This result implies that agricultural output price increases the effect of agricultural productivity on industrial output. This result then shows that with a better agricultural output price, there will be a significant positive impact of agricultural productivity on industrial output in SSA. In line with Tomek and Kaiser (2014), this study supported the premise that low agricultural output price has adverse implications for productivity in the sector and may worsen rural dwellers' welfare and standard of living and thereby translate to shortages in food production (Martin and Warr, 1990). Besides, evidence also shows that higher agricultural output price, which is favoured by the findings from this study, can be an obstacle to industrialization through high costs of industrial input supplies from agriculture (Fardmanesh, 2017). Thus, findings suggest that government intervention in the agricultural sector, particularly through output price support, becomes imperative.

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The result conforms to Preobrazhensky's (1926) first premise (P1) that a price policy in the form of a lower output price that forced a reallocation of resources from agriculture to industry will necessarily promote industrialization and subsequently raise national income in the short term and promote growth in the longer term. Nonetheless, such policies in the view of Martin and Warr (1990) may also impoverish the rural population and frequently lead to food shortages. The result corroborates the findings reported by Xie and Wang (2017) that changes in grain yield production in China are influenced by changes in agricultural product prices. It is also consistent with the findings of Miecinskiene and Lapinskaite (2014) that changes in commodity prices in the global market, especially the prices of aluminium, cocoa, coal, and oil, determine the changes in the aggregate price level in Lithuania. It is also in tandem with the result reported by Huka, Rouja, and Mchopa (2014) that price fluctuations in agricultural productivity are barriers to small-scale farmer growth, resulting in capital loss and farmers' shifting to other production activities. The findings also align with the result of Thiele (2003) that pricing policies, macroeconomic distortions, and certain non-price factors have a long-run relationship with agricultural productivity. It is also in line with Akanegbu's (2015) finding that agricultural price distortions have a major and negative effect on agricultural production.

The contribution of this study is manifold. The study's focus on SSA economies, often characterized by mono-product exports, predominantly agricultural, makes it highly relevant to the region's economic development challenges. It contributes to the understanding of how pricing mechanisms affect resource allocation and sectoral shifts, providing region-specific insights into this global economic transition. By exploring how agricultural price levels affect wage costs in industries, the study uncovers essential dynamics often overlooked in previous research. This study sheds light on the ongoing transition of workers from the primary-agrarian sector to industry and services in SSA. This transition is a critical aspect of the region's economic development, and the research contributes to a deeper understanding of this shift. It recognizes the continued dependence of the majority of the population in SSA on agriculture for their livelihoods. The study employs rigorous sophisticated econometric technique, specifically the SGGM estimation; as such, the study adds a valuable quantitative dimension to the existing literature, allowing for more precise conclusions and policy recommendations.

By demonstrating the amplifying effect of agricultural output prices on the relationship between agricultural productivity and industrial output, this study provides valuable policy implications. Policymakers can use these findings to design strategies that promote agricultural productivity and ensure stable output prices, which can, in turn, foster industrialization and economic growth. The findings inform strategies aimed at balancing sectoral growth and enhancing overall economic productivity. Additionally, the study suggests potential areas for future research, guiding scholars towards unexplored avenues in the field.

The study is limited by data availability and relies on the accuracy and dependability of the secondary sources from where the data are collected, including the Food and Agricultural Organization and the World Bank database for the World Development Indicators. The issue of data availability limited the scope of the study to the period of 1995–2022, and the countries covered were limited to thirty-six (36) out of the forty-eight sub-Saharan African countries. However, these limitations are not necessarily a threat to the result of the findings given the coverage of a substantial number of countries in the region and the sufficiency of the number of years.

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