Chapter 14
Improving Agricultural Productivity Growth in Sub-Saharan Africa

Olaide Rufai Akande, Hephzibah Onyeje Obekpa and Djomo-Raoul Fani

Abstract Improved agricultural productivity is central to achieving inclusive development, reducing poverty, and enhancing the living standards of most people in sub-Saharan Africa. Concerned by the declining state of agricultural productivity in this region, we pursue the question whether agro-processing activities and exports of raw agricultural materials have a backward linkages effect on agricultural production activities. And if the relationship exists how can it be more effectively used? The regression results indicate that increases in export of raw agricultural materials negatively influence productivity growth in agriculture. Consistent with the findings of other studies that agro-industrial growth in the sub-Saharan region faces several challenges, the response of agricultural production to agro-industrial activities was positive but inelastic. To overcome these challenges, improving the value of agricultural exports and thereby improving agricultural productivity growth are needed in policy, regulatory, and institutional frameworks across countries in the region that will enable agro-industrial development to become stronger; lead to the creation of opportunities for increased private sector engagement including through the formation of public–private partnerships for developing synergies; provide access to credit for participants along the agricultural value chain; provide rural infrastructure that reduces postharvest losses and transport costs and shorten transit time, while increasing overall rural mobility; support innovations and technology for developing competitive value chains; provide access to value-responsive markets; provide access to timely information for improving bargaining powers; establish organizations to reduce transaction costs; and lead to inclusion of women, poor, and/or marginal groups in the value chains. Overall, this strategy will be optimal when it concomitantly and yearly increases agro-industrial activities and decreases agricultural raw material exports by 2.5% of their existing values, given 1981 as the base year.

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14.1 Introduction

Growth theories emphasize the influential role of nonconventional inputs in accounting for productivity and income differences among output producing units. However, in contrast to the neoclassical growth theory, arguments based on the endogenous growth theory (Aghion and Howitt 1992; Grossman and Helpman 1991; Romer 1990) assume that differences in growth among economic entities using the same or similar inputs are accounted for by factors and disturbances within the growth model. By implication, therefore, policy interventions can be used to adjust suboptimal production.

In sub-Saharan Africa (SSA), agriculture remains the major occupation of most people, contributing to the population's food security and providing rural dwellers livelihood option. In many countries in the region, agriculture is the key source of foreign exchange and revenue for the government. If properly developed, agriculture also has the potential of stemming the current dangerous trend of rural-urban migration, reducing the numerous social problems in cities and spurring sustainable inclusive development. However, as in other regions of the world, the capacity of the sector to meet its potential critically depends on the growth of the agro-industry.

Agro-industrial development spurs growth in primary agricultural production because of the forward and backward linkages existing between these sectors (Hirschman 1958). Agro-processing in particular has several positive effects on agricultural production because it is a necessary part of the agricultural value chain. Thus, its absence retards the flow of value in an agricultural economy. Agro-industrial development also promotes job creation and inclusive development because of its potential to provide jobs for disadvantaged groups like women. Further, a growth in agro-processing reduces postharvest losses, thereby increasing incomes and helping people fulfill their economic aspirations. However, while agriculture-led growth has played an important role in reducing poverty and transforming the economies in many Asian countries, the strategy has not worked in Africa. For example, most African countries have failed to meet the requirements of a successful agricultural revolution. An obvious corollary to this is deep and prevalent poverty in the region as compared with the other regions in the world (Kharas 2007; Strawson et al. 2015; UNDP 2011).

Two mutually reinforcing problems are contributing to the high prevalence of poverty in the region: bad policies and low agricultural productivity. For instance, Fuglie and Rada (2013) point out that some of the lowest levels of agricultural land and labor productivity in the world are found in sub-Saharan Africa. Anderson and Masters (2009) say that farmers in many parts of Africa continue to face more discriminatory policies as compared with farmers in other global regions because farmers in the continent are confronted with policies that lower economic incentives to invest in agricultural production and modern inputs.

This situation stresses the need for strategies that stimulate more rapid agricultural growth in sub-Saharan Africa. However, increased exploitation of natural resources or a spike in commodity terms of trade may only spur limited growth in the long run. In contrast, policies anchored on key productivity determinants (Binswanger and Townsend 2000) can help maintain agricultural growth over the long run. In our paper, we pursue the question of how agro-industrial activities and exports of agricultural raw materials can be used to generate effective agricultural productivity growth in SSA. Our study differs from the literature on sources of total factor productivity (TFP) growth in agriculture in two aspects. First, we circumvent the simultaneity equation bias associated with TFP estimations from the panel data by using the hybrid Olley and Pakes (1996) and Levinsohn and Petrin (2003) procedure. Second, as against the deterministic forecasting approach in most studies, the simulation approach that we use acknowledges that uncertainties are associated with realization of values of some TFP determinants, and by extension, the random nature of TFP itself.

The rest of the paper is organized as follows. Section 14.2 presents the conceptual framework, while Sect. 14.3 gives details of the econometric model underlying the analysis. It also presents the estimated model and data sources. Section 14.4 discusses the results and gives a conclusion.

14.2 Agro-Industrial Development: A Conceptual Framework

14.2.1 Agro-Industrial Development and Productivity Growth

According to FAO (1997), agro-industry refers to a subset of manufacturing that processes raw materials and intermediate products derived from the agricultural sector. Agro-industry transforms products originating in agriculture, forestry, and fisheries and processes them into canned food, beverages, fruit juice, meat and dairy products, textile and clothing, leather wood and rubber products, and animal feed, among others.

Support for the development of agro-industry as a precursor to agricultural productivity growth is rooted in the “linkage hypothesis.” The original version of the theory of unbalanced growth pioneered by Hans Singer, Alfred Hirschman, and Wait Rostow emphasized the need for investments in strategic sectors of the economy instead of all the sectors simultaneously. In Hirschman’s (1958) view, the other sectors will automatically develop themselves through what are known as “linkage effects.” The implicit assumption is that the best development path for developing countries with income scarcity lies in selecting those enterprises and industries where progress will induce further progress elsewhere. By implication, therefore, any industry that shows a high degree of dependency as measured by the proportion of output sold to or purchased from other industries, can provide a strong stimulus to economic growth. Thus, where a complementary backward relationship exists between industry A and industries B and C, growth of output of industry A may generate demand for products of B and C and may also reduce the marginal cost of production in these industries.

Correspondingly, through its backward and forward linkages, the agro-industry can play a substantial role in spurring agricultural growth, providing employment in rural areas, ensuring food security, and stimulating innovativeness among farmers. According to FAO (1997), the agro-industry could spur productivity growth in agricultural production through market expansion because establishing processing facilities is an essential first step toward stimulating both consumer demand for processed products and an adequate supply of the needed raw materials. Second, the provision of transport, power, and other infrastructural facilities required for agro-industries also benefits the agricultural production process and enhances productivity. Ramachandran (2009) further states that agro-based industries can spark innovativeness among farmers by encouraging them to resort to new production techniques because the agro-industry helps agriculture become more productive by enlarging the supply of inputs like fertilizers, pesticides, and improved farm implements and equipment. The development of an agricultural output-based industry automatically encourages farmers to produce the concerned crops. In the absence of agro-based industries, the farmer community develops a sort of frog-in-the-well attitude toward farming (Ramachandran 2009).

Another important effect of agro-processing is a substantial increase in employment that may result from setting up an industry using raw materials. For instance, considerable employment may be generated in agriculture by being the raw material base, even if the agro-industrial process is itself capital-intensive (FAO 1997). In particular, food processing in the early stages of development can be an important direct complement to agriculture as a source of employment for seasonal labor. The off-farm employment opportunities provided by food processing may thus represent the first instrument of time-smoothing in the labor market and as such is an important factor of capital accumulation in rural areas. Ramachandran (2009) further argues that by helping provide employment opportunities locally, agro-industries stop the dangerous consequences of mass exodus of farmers and rural dwellers associated with rural-urban migration.

The agro-industry's capacity to generate demand and employment in other industries is also important because of its role in activating sideways linkages, that is, linkages derived from the use of by-products or waste products of the main industrial activity (FAO 1997). For example, animal feed industries can utilize several agro-industrial by-products such as whey, oilseed press cakes and blood, carcass and bone meat. In addition, many industries using agricultural raw materials produce waste that can be used as fuel, paper pulp, or fertilizers. Smallholder producers in developing countries have been experiencing high postharvest losses threatening their food security and negatively affecting the financial sustainability of their operations. For instance, the Africa Post Harvest Loss Index (2014) estimates that losses for roots and tubers were at 10–40%, for fruits and vegetables at 15–44%, while fish and sea food at 10–40%. Developing the agro-processing potential, either through indigenous knowledge (drying, salting, crushing, precooking) or modern technology-based methods (extraction, canning, bottling, concentration), has the capacity to reverse these losses. Therefore, agro-industrial activities also have the potential to contribute toward food security.

However, unplanned agro-industrial development may generate negative externalities and sustain primary agricultural production in a low level of equilibrium. For example, there may be significant risks in terms of equity, sustainability, and inclusiveness when value addition and capture are concentrated in the hands of a few value chain participants to the detriment of the others (da Silva and Baker, 2007). This will be the case in a situation of unbalanced market power in the agri-food chain. Moreover, sustainability of agro-industrial development depends on its competitiveness in terms of costs, prices, operational efficiencies, product offers, and other associated parameters. Establishing and maintaining competitiveness may constitute a particular challenge for small- and medium-scale agro-industrial enterprises and small-scale farmers.

The preconditions for developing agro-industries include necessary transportation, information, and communication technologies and access to reliable supplies of key utilities, notably electricity and water. Therefore, infrastructural constraints influence the cost and reliability of the physical movement of raw materials and end products, the efficiency of processing operations, and responsiveness to customer demands. The prevailing macroeconomic and business conditions and the level, quality, and reliability of infrastructure are also critical determinants of competitiveness in the export of processed agro-food products (Crammer 1999). In a situation of acute infrastructural constraints, the additional complexities of processing operations may outweigh the benefits of diversification in the exports of primary commodities toward value addition (Love 1983). Weak infrastructure may further put agro-processing enterprises at a competitive disadvantage vis-à-vis their industrialized competitors and distort the competitiveness of developing countries relative to one another. Unreliable and costly supplies of utilities may also prevent enterprises from operating at or near full capacity utilization. Overall, a weak infrastructural environment will lower the rate of transition of agro-industries from informal to formal operators and steer the structure of the sector toward a higher level of concentration.

14.2.2 Export of Agricultural Raw Materials and Productivity Growth

Arguments supporting commodities trade across international borders are rooted in the export-led growth hypothesis (see, Adams 1973; Crafts 1973; Edwards 1992, 1998). According to this model, export trade is a key determinant of economic growth. The key premise of this argument is that overall growth in a country can be generated not only by increasing the amount of labor and capital within the economy, but also by expanding exports. Accordingly, exports can serve as an "engine of growth." An offshoot of this idea is the assumption that developing countries have comparative advantages in agricultural production, thus only needing to forward their agricultural produce to international markets (Akande 2012). However, empirical analyses to confirm this proposition have shown mixed results. While positive for some countries (Krueger 1978; Lussier 1993), they were negative for others with more than half the empirical investigations published in the 1990s finding no long-run relationship between exports and economic growth, suggesting that correlations between these variables arise as a result of short-term fluctuations.

A critical factor that affects the chances of developing countries benefiting from export trade in agriculture is increasing consumer concerns about food safety. Specifically, food exports from the developing world are exposed to demanding food safety standards from organizations such as Codex Alimentarius and by unilateral requests from individual importers. Also, attitudes and standards in vogue in the developed world spill over to local markets (Pinstrup-Andersen 2000). A new form of protectionism often arises in which high quality and safety standards imposed by importing countries cannot be accommodated rapidly by local production technologies or guaranteed by local analytical capabilities. The latter may lead to increased levels of rejection at entry ports. Moreover, even if the problem regarding the safety of an imported food has been overcome, the credibility of the exporting country to produce safe food may be at stake, thus affecting the volume of its food exports. For this reason, developing countries that consider implementing or strengthening their food-borne disease controls and investigation and surveillance systems are unlikely to gain in the long run from food and agricultural export trade.

In summary, the review indicates that depending on the prevailing factors the correlation between agricultural productivity, agro-processing and raw material exports can be positive or negative and is also subject to random influence from market forces. Hence, the focus of this paper is establishing this correlation and how the equilibrium can be shifted in a way so as to achieve sustainable growth and inclusive development in SSA.

14.3 Econometric Framework and Data

The simulation approach examines the future evolution of TFP in SSA agricultural production under the assumption that uncertainties are associated with the evolution of certain TFP determinants (Davidson and MacKinnon 2004). First, we estimated the TFP data from the aggregate agricultural production function using the hybrid Olley and Pakes (1996) and Levinsohn and Petrin (2003) procedure. Second, the fixed coefficients in the TFP simulation model were estimated from a Tobit regression. Finally, the impact of varying scenarios of agro-processing activities and raw material exports on TFP's evolution under uncertainties were forecast using the Monte Carlo simulation. The random values of the uncertain variables in the simulation model were generated from their probability distribution functions (PDF).

Specifically, the simulated TFP (θ) model is:

$$\begin{gathered}\theta = E[f(X_{it})], X \sim \mathrm{PDF}(X_{it}) \text{ or} \\ E(f(X_i)) = \acute{\theta}_N = \frac{1}{N}\sum_{i=1}^{N} f(X_{it})\end{gathered} \tag{14.1}$$

where X is a vector of TFP determinants.

By the law of large numbers, the approximation $\acute{\theta}_N$ converges to the true value as N increases to infinity. Therefore, the $\acute{\theta}_N$ estimate is unbiased if:

$$E(\acute{\theta}_N = \theta)$$

As a first step, agricultural TFP was estimated from the hybrid Olley and Pakes-Levinsohn and Petrin production function:

$$y_{it} = \beta_{oi} + \beta_k k_{it} + \beta_l l_{it} + \beta_{ld} ld_{it} + \omega(k_{it}, i_{it}) + u_{it}^{q}. \tag{14.2}$$

where lower case letters represent the log transform of the respective variable, y is gross domestic product measured in million purchasing power parity in dollars (PPP\$); k is the gross capital investment measured in million US dollars; l is agricultural labor measured in million people employed in agriculture; ld is agricultural land measured in square kilometers; i is gross agricultural investment measured in million US dollars; u is the error term $\sim N(0, \sigma^2)$.[1]

The fixed parameters in the TFP simulation model were estimated from the Tobit regression:

$$\begin{aligned}\mathrm{tfp}_{it}^{*} = {} & \alpha_{oi} + \alpha_1 * \mathrm{agvadd}_{it} + \alpha_2 * \mathrm{agrmtexpt}_{it} + \alpha_3 * \mathrm{agr\&d}_{it} \\ & + \alpha_4 * \mathrm{agfdi}_{it} + \alpha_5 * \mathrm{agoda}_{it}\end{aligned} \tag{14.3}$$

where α_{0i} are fixed effects parameters on countries; $\alpha_{(j:j>0)}$ are parameters on the associated variables; agvadd is value addition to agricultural products through agro-processing measured in current market prices (USD); agrmtexpt is the value of agricultural raw materials exported measured in current US dollars; agr&d is the public expenditure on agricultural research and development measured in million constant 2011 US dollars; agfdi is the value of foreign direct investment in agriculture measured in current US dollars; agoda is the value of official development

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[1] Annexure A gives a derivation of this model.

assistance to agriculture measured in constant 2012 US dollars; ε_{it} is the error term $\sim N(0, \sigma^2)$.

Finally, TFP was simulated from the stochastic model:

$$\begin{aligned}\text{tfp}^*_{it} = {} & \alpha_{oi} + \alpha_1 * \left(\text{agvadd}_{it} + \eta_{1,it}\right) + \alpha_2 * \left(\text{agrmtexpt}_{it} + \eta_{2,it}\right) \\ & + \alpha_3 * \text{agr\&d}_{it} + \alpha_4 * \text{agfdi}_{it} + \alpha_5 * \text{agoda}_{it} + \xi_{it}\end{aligned} \tag{14.4}$$

where $\eta_{1,it}$ and $\eta_{2,it}$ are uncertainties associated with measurements of agro-processing and agricultural raw material exports, respectively. They are expected to capture random events associated with these business and open economy variables. ξ_{it} is an exogenous white noise disturbance in the model.

Given the stochastic nature of this model, the behavior of TFP growth under various scenarios was investigated. The simulated scenarios consisted of concomitant yearly positive changes to the state of agro-processing activities and decreases in exports of agricultural raw materials by 1, 2.5, 5, 7.5, and 10% with 1981 as the starting point.

14.3.1 The Data

Data for the study is the longitudinal time series or panel data on 13 countries in sub-Saharan Africa. The data covered the period 1981–2005. Data was collected from the databases of the Food and Agriculture Organization (FAO) of the United Nations, Agricultural Science and Technology Indicators (ASTI) (www.asti.cgiar.org), and the World Bank (www.worldbank.org). Data on agricultural raw materials exported was derived by multiplying the proportion of agricultural raw materials in the total merchandize export by the total merchandize export. The value of agro-industrial value addition was proxied by the industrial value added. This was obtained by multiplying industrial value added as a proportion of GDP by the GDP. Values of official development assistance in agriculture (agoda) and foreign direct investment in agriculture (agfdi) were obtained by weighting the aggregate of these variables by the proportion of agriculture value added in GDP.

14.4 Results and Discussion

14.4.1 Results

Annexure B summarizes the data, while Table 14.1 and Table 14.2 give estimates from production function and the TFP model. The goodness of fit statistics of the hybrid Olley and Pakes-Levinsohn and Petrin production function indicates a good fit of the data to the model. The returns to scale statistics show that agricultural

Table 14.1 Parameter estimates of hybrid Olley and Pakes-Levpet and Petrin regression model of agricultural production in sub-Saharan Africa

Variable[a]	Coefficient	Std. error	Sig. level
Labor	0.72	0.36	0.05
Land	−0.16	0.46	0.74
Gross capital	1	0.42	0.02
Investment	0.001	0.10	0.99
Wald	0.43(0.43)		SS

Source Author's computation

[a] All variables are in logarithm form

Table 14.2 Parameter estimates of the Tobit regression model of TFP in SSA's agriculture

Variable	Mixed effects model	Random effects model
	Coefficient (std. error)	Coefficient (std. error)
agr&d	−0.15(0.05)**	−0.133(0.032)***
Agoda	0.04(0.02)**	0.027(0.021)
Agfdi	−0.004(0.001)*	−0.004(.002)**
Agvadd	0.09(0.02)**	0.034(0.024)
Agrmtexpt	−0.04(0.01)***	−0.032(0.013)**
Burkina Faso	−1.56(0.05)**	
Madagascar	−2.35(0.06)*	
Ghana	−0.37(0.07)*	
Mali	−1.42(0.06)*	
Togo	0.06(0.05)**	
Kenya	−1.47(0.09)*	
Nigeria	−1.20(0.14)	
Malawi	−0.80(0.07)*	
sigma_u	$2.68e^{-19}$(1.00)	0.79(0.206)***
Sigma_e	0.12(0.01)***	0.12(0.01)***
Rho	$4.81e^{-36}$($3.69e^{-19}$)	0.98(0.01)
Fit stat.:		
Log likelihood	90.23	63.96
AIC	−150.46	−113.92
BIC	−106.01	−93.18
Wald Chi-square	7163.81***	29.96***
Likelihood ratio (LR)	52.54***	

Source Author's computation

***(**)(*)—significant at 1, 5, 10%

production in SSA exhibits constant returns to scale. The coefficients on labor and gross capital were significantly different from zero, whereas those on land and investment were not significant. Specifically, the elasticity coefficient on labor indicates that a percentage increase in the variable increased aggregate agricultural production by 0.71%. A percentage increase in capital on the other hand increased the value of agricultural production by the same percentage. In other words, this implies that agricultural output changed at the same rate as gross capital. This result is consistent with the findings of Grilliches (1998) that if TFP is correctly estimated, the coefficient on capital should be roughly equal to unity. The negative but insignificant coefficient on the land variable points to the potential for productivity depletion arising from extensive land use practices without corresponding nutrient replenishment through the use of fertilizers and other soil additives. These results support Nkamelu's (2013) findings that the land extensification path in Africa is rapidly becoming unsustainable or impractical as land grows scarcer.

The estimated TFP Tobit model indicates a good fit of the model to the data. The likelihood ratio (LR) test showed a better fit of the mixed effects model relative to the random effects model (LR = 52.54; $P \leq 0.01$). Other fitness parameters of the model, including log likelihood, the Akaike information criteria (AIC) and the Swatch information criteria also selected the mixed effects Tobit model in preference to the random effects model.

The elasticity coefficients on agro-industrial value addition and on export of agricultural raw materials for the mixed effects Tobit model were statistically significant. Specifically, the coefficient on value addition through agro-processing was positive indicating that intensification of agro-processing activities improved agricultural production in SSA. In contrast, the negative coefficient on raw material exports points to the fact that increasing exports of agricultural raw products has a decreasing effect on productivity of the agricultural sector in the region. Moreover, the coefficients of the control variables including public investment in agricultural R&D, agricultural development assistance, and foreign direct investment in agriculture were statistically significant. However, while the coefficient of value of development assistance to agriculture was positive, those of R&D and foreign direct investment in agriculture were negative. These negative coefficients suggest that excess public investments in research and development crowd out private participation while the level of investments by foreign nationals in the agricultural sector is inconsistent with the growth of the agricultural economy in sub-Saharan Africa.

The simulation (Table 14.3 and Fig. 14.1) revealed that policies that yearly and concomitantly increase agro-industrial value addition and reduce agricultural raw material exports by 2.5%, assuming 1981 as the base year, will lead to acceptable progressive growth in TFP in agriculture in SSA.

14.4.2 *Discussion*

Evidence from the regression analysis points to the fact that increases in agro-processing activities and its corollary decrease in the export of raw agricultural materials increase agricultural production in SSA. However, the low elasticity coefficient on value addition (less than unity) implies that agricultural productivity in the region responds little to changes in value addition activities, which further

Table 14.3 Scenario analysis of the effect of increases in agro-industrial activities and decreases in export of agricultural raw materials on TFP in sub-Saharan Africa

Scenario (% increase in agro-processing plus corresponding % decrease in agric raw materials export)	Percentage of progressive growth in TFP over the baseline (total)	Percentage of progressive growth in TFP over the baseline (marginal)
Baseline	0	0
1	1.33	1.33
2.5	8	3.2
5	13.33	2.67
7.5	20	2.67
10	21.33	2.13

Source Author's calculation

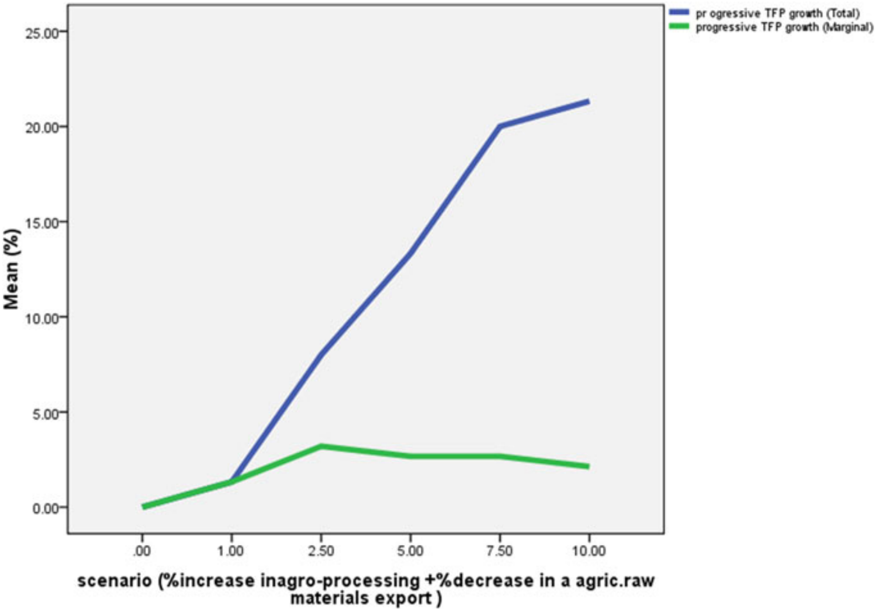

Fig. 14.1 Effect of improving agro-industrial activities and decreasing agricultural raw material exports on progressive growth of TFP in agriculture in SSA

suggests that the growth of agro-industry in SSA faces some challenges. AfDB (2008), the World Bank, and Information Development/Agribusiness (2013) identified the challenges including lack of infrastructure, storage, finance, competencies, adequate technologies, and a good policy environment which confront agro-industrial development in many parts of Africa. Specifically, these studies say that lack of storage capacity in conjunction with poor rural electrification and water access, insufficient road networks, and difficult access to communication tools (telephone, e-mail, etc.) affect the competitiveness of the final agro-processing products in terms of costs, quality, and supplies. Low and unstable agricultural productivity in Africa further constrains the success of the agro-industry.

Moreover, the level of capacity building in agro-processing in sub-Saharan Africa is low with the focus being on production extension. This partially explains the high percentage of postharvest losses apart from lack of appropriate logistics and storage capacity. Public R&D has also focused on production and prioritizing investments in agricultural research extension but not in postharvest and food technology. Most ongoing agricultural operations in Africa (especially at the small-medium farmer level) continue to be focused on production aspects with no forward linkages. And, in most cases, agro-processing at the rural level in Africa ranges from nonexistent to just very basic. This is linked to the fact that access to agro-processing technologies is very limited due to lack of expertise/know-how and affordable costs. Besides, due to poor infrastructure, production factors such as water, electricity, and diesel-petrol are either not available or very expensive. The high costs of these production factors affect the availability, quality, and cost of other key inputs like packaging materials in the agro-industry.

Further, accessing technologies is not always affordable because taxation systems in many African countries overload the imported costs of agro-industry equipment. There is also a challenge in incorporating certification systems that could fulfill the local-regional requirements in the first phase and regional and international requirements at a later stage if the final target is the export market. A typical African farmer has no expertise in this area because his priority has been simple production so far.

Africa's business environment is also characterized by limited financial resources, which has direct implications for industrial development. Commercial banks work at very high rates which are unaffordable for many small-medium entrepreneurs. These financial constraints are further magnified when start-up businesses in agro-industry have to be serviced. Many African countries are still at a very low position in rankings on ease of doing business. This in some cases can stop foreign agro-processing investors, and also make it difficult to access technologies and equipment. Licensing, business start-up costs, trade procedures, and time required are worse in sub-Saharan Africa as compared with other developing regions.

Overcoming these challenges for successful agro-industrialization requires carefully chosen policy strategies. The solution to this problem must start with the policy environment recognizing that appropriate infrastructure together with capacity building are the key pillars that can successfully decrease postharvest losses and serve as an initial trigger for attracting private sector investments. Road and market infrastructure is also important as they provide critical linkages for connections and transactions between value chain participants besides the other rural functions that they perform that indirectly support the development of the value chain. While roads are useful for value chains, they must connect agricultural areas with competitive advantage to strategic markets.

Similarly, more infrastructure for production (irrigation schemes, dams) is needed in SSA to increase production, making it more cost-effective and fulfilling the demands of volume and quality of the agro-industry. The needed policy strategy must consider strengthening market intelligence and market linkages and make them sustainable, especially in rural areas. An enabling environment must also be established for developing the value chain through policies, regulations, and supporting institutions. To facilitate increased private sector engagement, greater clarity is needed on the evolving and expected roles of the public and private sectors. Public–private partnerships can support the development of agriculture value chains, but require significant inputs to identify opportunities and implementation arrangements.

Extension support services also need to be closer to a business development model than the traditional agricultural extension model; they should also be able to bring the market and value addition needs to the farmer and the small-medium agro-processor level. Farmers' associations and cooperatives based on the scale economy could also overcome the gaps that individual farmers cannot. However, the challenge may be how to promote and support them in a sustainable way and how to equip them with a comprehensive tool package (finance and marketing services, technical and managerial skills, extension services) that could make them competitive enterprises.

Access to credit is a key requirement for all participants in a value chain just as access to timely market information such as on prices and is essential for a functioning value chain. This helps participants like producers in the chain to respond to changes in market prices and improves their negotiating powers with traders and processors. The creation of free trade areas at the regional level can help overcome problems when local equipment is required, but still the challenge is how to make international technology available and affordable without undermining the potential emergence of local technology providers.

14.4.3 Limitations and Suggestions for Further Studies

The limitation of our study is associated with the fact that the findings may be affected by the quality of the data used. Specifically, nonavailability of data on many variables and missing data reduced the number of countries used for the analysis. A more precise estimate may be obtained by a study that uses datasets with improved quality.

14.4.4 Conclusion and Recommendations

This paper investigated the question of how agro-processing and agricultural raw material exports can be effectively used to improve productivity of agriculture in

SSA. Our findings lead to the conclusion that while intensifying efforts in exporting raw agricultural materials lead to decreased productivity growth in agriculture, increasing agro-processing activities marginally lead to improved agricultural productivity growth, suggesting that agro-industrial activities are locked in a low level of equilibrium.

To overcome the challenges associated with agro-industrialization and improving the value of agricultural exports thereby improving agricultural productivity growth, there is a need for a policy, regulatory, and institutional framework across countries in the region that enables agro-industrial development to become stronger; creating opportunities for increased private sector engagement including through the formation of public–private partnerships for developing synergies; providing access to credit for participants along the agricultural value chain; providing rural infrastructure that reduces postharvest losses and transport costs and shortens transit time while increasing overall rural mobility; supporting innovations and technology for developing competitive value chains; providing access to value-responsive markets; providing access to timely information to improve bargaining powers; establishing organizations to reduce transaction costs; and including women, poor, and/or marginal groups into value chains. This strategy will have optimal results if it concomitantly and yearly increases agro-industrial activities and decreases agricultural raw material exports by 2.5% from their existing values.

Appendix 1: Model Derivation

In deriving TFP data as Solow's residuals, the aggregate agricultural production function was conceived as,

$$Y_{it} = A_i K_{it}^{\beta_k} L_{it}^{\beta_l} \tag{14.5}$$

where Y is the aggregate output, K is the vector of capital input, L is the labor input, A is the Hicksian neutral efficiency level.

While Y, K and L are all observed by an econometrician, A is not observed by a researcher. Taking the natural logarithm results of Eq. (14.5) yields:

$$y_{it} = \beta_{0i} + \beta_k k_{it} + \beta_l l_{it} + \varepsilon_{it} \tag{14.6}$$

where the lower case letters refer to the natural logarithm of respective variables and $\ln(A) = \beta_{0i} + \varepsilon_{it}$. Where β_{0i} measures productivity that varies over countries, and ε_{it} s, the time specific deviation from that mean. When ε_{it} is decomposed into a predictable and unpredictable component, Eq. (14.6) becomes:

$$y_{it} = \beta_{0i} + \beta_k k_{it} + \beta_l l_{it} + v_{it} + u_{it} \tag{14.7}$$

where $\omega_t = \beta_{0i} + v_{it}$ represents sector specific productivity and u_{it} is a iid error term, representing unexpected deviation from the mean due to measurement or other unexpected circumstances. The task is to estimate Eq. (14.7) and solve for ω_t. TFP can then be calculated by exponentiating (ω_t) and then expressing it as a function of its relevant determinants such as:

$$\text{TFP} = g(X), \tag{14.8}$$

where X is a vector of TFP determinants.

Estimation of Eq. (14.7) using the OLS technique on panel data from continuing firms or countries faces three particular difficulties: multi-collinearity, selection, and simultaneity bias. An endogeneity or simultaneous equation bias arises because investments in inputs are likely to be correlated with past productivity shocks. Specifically, endogeneity occurs because productivity is known to profit maximizing firms (but unknown to an econometrician) when they choose their input levels (Marschak and Andrews 1944). Production units will increase their use of inputs as a result of positive productivity shocks. Under this condition, any unobserved shock to productivity that raises output could indirectly raise investments on inputs, inducing a correlation between the explanatory variables and the error term in the productivity equation. Moreover, if no allowance is made for entry and exist owing to productivity shocks, a selection bias will emerge (Van Beveren 2012). The implication of this is that the production elasticities of the observed factors are not identified because the compound error v_t an u_t are not identically and independently distributed. Therefore, parameter estimates of the production function with OLS will be biased. Specifically, input coefficients will be biased upward if there is serial correlation in productivity shock, ω_t (Petrick and Closs 2013). This effect will be stronger, the easier to adjust input use in response to productivity shocks.

Several approaches have been proposed to overcome these problems. Arellano and Bond (1991) suggest the instrumental variable-based estimator. Within estimators have also been employed in studies on productivity of R&D investments. Olley and Pakes (1996) developed a semi-parametric estimation algorithm using investment and age as proxy for productivity. Levinsohn and Petrin (2003) contribution to Olley and Pakes' (1996) semi-parametric estimator by using material as an alternative to investment proxy. However, the shortcoming of the fixed effects estimator is that it overcomes the simultaneity problem only if we are willing to assume that the unobserved, firm specific productivity is time invariant (Yasar et al. 2008). Moreover, the within and difference estimator may remove too much variance from the data and render the estimation impracticable. The strength of Olley and Pakes' (1996) algorithm is that it explicitly takes both the selection and simultaneous problem into account by taking cognizance of the idiosyncratic productivity shocks and exit behavior of the production unit. In this model, a firm is assumed to maximize the expected discounted value of net cash flows (Van Beveren 2012). The investment exit decision will depend on the firm's perception about the distribution of the future market structure given the information currently available. To achieve consistency a number of assumptions have been further made. First, the productivity of the firm is assumed to be the only state variable, evolving through the first-order Markov process. Second, a monotonicity assumption is imposed on the investment variable to ensure stability of the investment demand function. Therefore, investment increases in productivity are conditional on the values of all the state variables. Consequently, only nonnegative values of investments can be used in the analysis. Moreover, if industry-wide prices are used to deflate the input and output measured in value terms to proxy their respective quantities, it is implicitly assumed that all firms in the industry face common prices (Ackerberg et al. 2007).

Overall, the investment decision will depend on capital and productivity as:

$$I_{it} = i_t(k_{it}, \omega_{it}) \tag{14.9}$$

where lower case letters represent the logarithmic transformation of variables. If we assume that investment is strictly increasing with respect to productivity, conditional on capital, the investment decision can be inverted to allow the expression of the unobserved productivity as a function of the observables such that:

$$\omega_{it} = i_t(k_{it}, i_{it}) \tag{14.10}$$

where $h_t(.) = I_t(.)$.

Given this understanding, Eq. (14.7) can be written as:

$$Y_t = \beta_0 + \beta_l l_{it} + \beta_k k_{kt} + h_t(i_{it}, k_{it}) + u_t^q \tag{14.11}$$

Next, if we define the investment function $\varphi_t(k_{it}, i_{it})$ as follows:

$$\varphi_t(k_{it,}, I_{it}) = \beta_0 + \beta_k k_{kt} + h_t(I_{it}, K_{it}) + u_t^q$$

Then, Eq. (14.11) can be rewritten as:

$$Y_t = \beta_l l_{it} + \varphi_t(i_{it}, k_{it}) + u_t^q \tag{14.12}$$

Estimation of Eq. (14.11) proceeds in two stages (Olley and Pakes 1996). In the first stage, output (value added) is regressed on log of labor and capital and a polynomial function of investment and capital (i and k) to obtain a consistent estimate of the labor elasticity parameter and $\varphi_t(k_{it}, I_{it})$, the combined effect of capital and efficiency or productivity level. By this action, the estimated labor coefficient and other included free variables are expected to be lower since this corrects for downward bias in capital (Hall and Mairesse 2007; Van Beveren 2012).

The second stage of the estimation process, which recovers the coefficient on capital variable, exploits the information on firm dynamics. Specifically, productivity is assumed to follow a first-order Markov process, that is, $\omega_{it+1} = E(\omega_{It+1}|\omega_{it} + \xi_{it+1})$.

where ξ_{it+1} represents the news component assumed to be uncorrelated with productivity and capital in period t + 0.1. Firms will continue to operate provided their productivity levels exceed the lower bounds.

$\chi_{it+1} = 1 \geq \omega_{it+1} \geq \underline{\omega}_{it+1}$ where χ_{it+1} is a survival indicator variable. Because the news component ξ_{it+1}, is correlated with freely variable inputs, in the analysis labor and other freely variable inputs are subtracted from the output. Therefore, the analysis considers the expectation of:

$$\begin{aligned} &E\left[(y_{it+1} - \beta_l l_{it+1})|k_{it+1}, \chi_{it+1} = 1\right] \\ &\quad = \beta_0 + \beta_k k_{it} + E\left[\omega_{it+1|\omega_{it.}} \chi_{it+1} = 1\right] \end{aligned}$$

The second stage of the estimation algorithm is then derived by using the law of motion.

In contrast to Olley and Pakes' (1996) decision to use investment as proxy for productivity, Levinsohn and Petrin (2003) relied on intermediate inputs as proxy. Second, their estimation does not correct for selection bias.

In our study, a hybrid Olley and Pakes (1996) and Levisohn and Pakes (2003) estimator was implemented. Specifically, the model is similar to the Olley and Pakes (1996) estimator in terms of employing investment as a proxy for productivity. It resembles Levinsohn and Petrin (2003) as it does not correct for selection bias. The latter is consistent with the aggregate nature of the data used.

Appendix 2: Data Summary Statistics

See Table 14.4.

Table 14.4 Summary statistics of the data

Country: Benin Rep.	Mean	Std. dev.	Min	Max
Agricultural GDP	2506.621	546.5719	1494.044	3162.646
Raw materials export	2.70e+08	1.08e+08	2,983,042	4.21e+08
TFP	1.008466	0.1942747	0.7939172	1.404898
Burkina Faso				
Agricultural GDP	3119.91	990.331	1435.468	4184.47
Raw materials export	1.68e+08	1.04e+08	2.53e+07	3.62e+08
TFP	0.9114271	0.2677091	7.18e−16	1.142234
Madagascar				
Agricultural GDP	3316.498	415.5445	2538.141	3980.411
Raw materials export	2.32e+07	1.34e+07	3231.464	5.87e+07

(continued)

Table 14.4 (continued)

Country: Benin Rep.	Mean	Std. dev.	Min	Max
TFP	0.988527	0.472788	0.8466374	1.074218
Ghana				
Agricultural GDP	6883.188	1316.675	4959.785	9789.318
Raw materials export	1.58e+08	7.88e+07	1.52e+07	2.48e+08
TFP	3.76258	9.772114	0.6393817	34.79007
Mali				
Agricultural GDP	2840.574	515.3017	1957.09	3426.025
Raw materials export	3.29e+08	1.81e+08	8.33e+07	5.24e+08
TFP	0.9706709	0.0782413	0.8783707	1.109699
Togo				
Agricultural GDP	1356.446	350.0368	819.9999	2016.686
Raw materials export	8.00e+07	4.97e+07	1.34e+07	1.76e+08
TFP	5.70297	20.34471	0.2488871	92.08675
Kenya				
Agricultural GDP	9471.444	1797.619	6628.193	11,837.5
Raw materials export	1.38e+08	9.73e+07	5.53e+07	4.25e+08
TFP	0.948233	0.20344	0.0231489	1.125005
Nigeria				
Agricultural GDP	42,000.04	9416.445	25,909.01	57,168.83
Raw materials export	3.49e+07	6.54e+07	1,108,543	2.60e+08
TFP	1.018321	0.1350183	0.695404	1.195999

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