# SUBSISTENCE AGRICULTURE AND LABOUR REALLOCATION IN DEVELOPING COUNTRIES

by

Obed Owusu

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*To my lovely wife (Nana Ama Pokua), son (Nana Kwame), and daughter (Maame Abena Kwanowah)*

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## Abstract

This dissertation examines the economic determinants of labour reallocation in Sub-Saharan African (SSA). I first document the historical trends in labour reallocation in 11 countries in SSA and use a general equilibrium model to quantitatively assess the extent to which standard theories can account for labour reallocation in SSA. The analysis shows that structural change has been slow in SSA and this was due to a combination of low productivity level in agriculture and slow productivity growth in non-agriculture. Moreover, standard theories can explain 50% of the decline in the share of employment in agriculture in only 40% of the sampled countries. Next, I study farm-level productivity in five countries in SSA. Using an empirical production function approach, I test if there are total factor productivity (TFP) differences across the subsistence and commercial-farm types and quantitatively assess the implications of farm commercialization for labour reallocation. The analysis shows no substantial differences in TFP across farm types. In the most "optimistic" case of Ghana, TFP is about 15% higher in commercial farms than subsistence farms. A counter-factual analysis of a 15% increase in agricultural productivity could lead to at most a ten percentage points reduction in the share of employment in agriculture in Ethiopia, Malawi, and Tanzania. Finally, I examine farm-level factors that stimulate agricultural commercialization in SSA. In particular, I estimate the likelihood of being a commercial versus a subsistence farmer and the likelihood of transitioning from one farm type to another based on observable characteristics. The analysis shows that although a substantial proportion of farms has no market participation in a given year, there are rich transition dynamics over time. The results from the probit regression show that resource endowments (land, labour, chemical use) and farm characteristics such as multiple-cropping, irrigation, crop type (fruits, vegetables, cash crops), and farm machinery use are positively correlated with market participation and the transitioning of subsistence farms into the market economy.

## List of Abbreviations Used

| | |
|---|---|
| CRS | Constant Return to Scale |
| DEA | Data Envelop Analysis |
| FAO | Food Agriculture Organization |
| FAOSTAT | Food Agriculture Organization Statistics |
| FASDEP | Food and Agricultural Sector Development Policy |
| GDP | Gross Domestic Product |
| GGDC | Groningen Growth and Development Centre |
| GPRS | Growth and Poverty Reduction Strategy |
| HYV | High Yielding Variety |
| LSMS | Living Standards Measurement Survey |
| OLS | Ordinary Least Square |
| PPP | Purchasing Power Parity |
| PWT | Penn World Table |
| RMSE | Root Mean Square Error |
| SFA | Stochastic Frontier Analysis |
| SSA | Sub-Saharan Africa |
| SE | Standard Error |
| TE | Technical Efficiency |
| TFP | Total Factor Productivity |

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# Chapter 1

# Introduction

Labour reallocation across sectors (also known as structural change) has been an important determinant of economic growth in modern society, especially, as labour moves from "low productivity" to "high productivity" sectors. In Sub-Saharan African (SSA), the share of employment in agriculture is high and labour productivity is low, and this dissertation broadly examines the economic determinants of labour reallocation in 11 countries in SSA. It is composed of three related chapters.

Chapter 2 documents the historical trends in labour reallocation in 11 countries in SSA: Botswana, Ethiopia, Ghana, Malawi, Kenya, Mauritius, Nigeria, Senegal, South Africa, Tanzania, and Zambia. Using a general equilibrium model that integrates the demand-side and supply-side drivers of structural change, the chapter quantitatively assesses the extent to which standard theories of structural change can account for labour reallocation in SSA over the past 40 years. The demand-side drivers of structural change arise from differences in income elasticity of demand across final goods. The supply-side drivers arise from differences in sectoral productivity growth combined with complementarities between agriculture and non-agricultural goods. The analysis shows that structural change has been slow in SSA and this was due to a combination of low productivity level in agriculture, slow (even negative) productivity growth in non-agriculture, and despite these adverse conditions, an increasing share of employment in non-agriculture.

Moreover, standard theories of structural change can explain about 50% of the decline in the share of employment in agriculture in only 40% of the sampled countries. A counter-factual analysis replacing sectoral productivity growth rates in SSA with the corresponding sectoral productivity growth rates from South Korea shows that raising productivity in SSA to levels seen in other rapidly growing economies is essential for faster structural transformation in SSA. A key conclusion of this chapter is thus while labour released by agriculture is critical to structural change, low productivity level in agriculture and slow productivity growth in non-agriculture has slowed down the pace of labour reallocation in SSA.

Chapter 3 examines the causes of anemic productivity in agriculture in SSA. This chapter is mainly motivated by the observation that, in many developing countries, agricultural productivity is low by international standard and agricultural commercialization has been made a policy priority to raise productivity in agriculture. However, the causes and consequence of agricultural commercialization in SSA are poorly understood, with no systematic evidence on the merits of commercialization in raising productivity. This chapter thus studies farm-level productivity in five countries in SSA. The countries comprise Ethiopia, Ghana, Malawi, Nigeria, and Tanzania. The chapter distinguishes between two farm types, commercial and subsistence farms, and uses nationally representative cross-sectional data from the Living Standards Measurement Study-Integrated Surveys on Agriculture. The chapter first characterizes the production technology of farms using an empirical production function approach and tests if there are TFP differences across the subsistence and commercial-farm types. This approach contrasts micro-level studies on SSA that have primarily focused on productivity differences across small and large farms, and this is important for several reasons. First, if there are productivity differences across farm types, over time, agricultural labour may reallocate from the low productivity sector (subsistence) to high productivity (commercial) sector, which will, in turn, raise aggregate agricultural productivity. The labour reallocation process may not necessarily be from small to large farms. Second, aside from the fact that integrating traditional establishments into commercial activities is key to economic development, the subsistence-commercial dimension broadly mimics the traditional-modern duality observed in agriculture in many countries in SSA. Third, this approach provides a framework to quantitatively assess the implication of farm commercialization for labour reallocation across sectors.

The findings show that despite the existence of substantial differences in inputs use, subsistence and commercial farms are characterized by similar production technology, and TFP is not significantly different across the two farm types. In the most "optimistic" case of Ghana, TFP is about 15 higher in commercial farms than subsistence farms. A counter-factual analysis of a 15% increase in agricultural productivity through farm commercialization could lead to at most a ten percentage points reduction in the share of employment in agriculture in Ethiopia, Malawi, and Tanzania. Overall, to raise productivity in agriculture, there must be a uniform shift across all farm types towards the adoption of modern (but sustainable) agricultural inputs supported by government policies directed to improving farming production techniques across all farm types.

Even while TFP difference between the subsistence and commercial farm types is negligible, a large number of subsistence farmers remains outside the market economy and national policies have emphasized the need to bring them into the fold of commercial agriculture. Improving market access may help induce greater farm commercialization and thus more significant investment in agriculture. However, there is little empirical evidence on farm-level factors that stimulate agricultural commercialization in SSA. Using a nationally representative panel data from the Living Standards Measurement Study-Integrated Surveys on Agriculture, chapter 4 of the dissertation estimates the likelihood of being a commercial versus a subsistence farmer and the likelihood of transitioning from one farm type to another based on observable characteristics.

The analysis demonstrates that although a substantial proportion of farms has no market participation in a given year, there are rich transition dynamics over time. The results from the probit regression show that resource endowments (land, labour, chemical use) and farm characteristics such as multiple cropping methods, irrigation use, crop type (fruits, vegetables, cash crops) and farm machinery use are positively correlated with market participation and the transitioning of subsistence farms into the market economy. Overall, policies aimed at improving farmers' access to resources and promoting sustainable smallholder agriculture could be instrumental in raising productivity in agriculture and enhancing marketable agricultural output.

The rest of the dissertation is as follows. Chapter 2 documents the historical trends in labour reallocation in 11 countries in SSA and uses a general equilibrium model to quantitatively assesses the economic determinants of labour reallocation in SSA. Chapter 3 studies farm-level productivity differences across the commercial and subsistence farm types and quantitatively assesses the implications of farm commercialization for labour reallocation in five countries in SSA. Chapter 4 investigates the determinants of transitions between subsistence and commercial farming in Nigeria and Tanzania. Chapter 5 concludes the dissertation along with additional details on data and supplementary results in appendices A, B and C.

# Chapter 2

## Structural Change in Sub-Saharan Africa: A Quantitative Assessment of Traditional Theories

### 2.1 Introduction

Structural change, defined as a secular decline in the shares of employment in agriculture and income in agriculture, has been a defining feature of economic development. For example, in the United States, the share of employment in agriculture declined from 74% in 1800 to less than 2% by 2010 (see İşcan, 2011). Similar patterns of changing employment and economic structure have been documented in many industrialized and emerging economies. Structural change is also seen as an important determinant of economic growth, especially, as labour moves from "low" productivity to "high" productivity sectors.[1]. In Sub-Saharan Africa (SSA), the share of employment in agriculture is high (over 50% in 2010) and agriculture continues to have low value-added per worker and largely for subsistence (see section 2.3.2). This chapter thus examines the economic determinants (demand-side and supply-side forces) of labour reallocation from agriculture to non-agriculture in 11 countries in SSA. The countries comprise Botswana, Ethiopia, Ghana, Malawi, Kenya, Mauritius, Nigeria, Senegal, South Africa,

[1]See for example Lewis (1954); Lewis (1980); Buera and Kaboski (2009), McMillan and Rodrik (2011); Duarte and Restuccia (2007); Gollin, Lagakos, and Waugh (2011). Kuznets (1957); Gollin, Parente, and Rogerson (2002), Temple and Wößmann (2006); Block (2010); Headey, Bezemer, and Hazell (2010); Diao and McMillan (2015).

Tanzania, and Zambia. The chapter makes two important contributions. First, it documents the historical trends in labour reallocation in 11 countries in SSA from 1970 to 2010. Second, using a three-sector (agriculture, manufacturing, and services) general equilibrium model, it quantitatively assesses whether standard theories of structural change can account for labour reallocation in SSA.

The model integrates two key drivers (complementary explanations) of structural change: differential demand growth across sector (demand-side) and differential productivity growth across sectors (supply-side). The demand-side driver of structural change arises from productivity growth in agriculture combined with a low-income elasticity of demand for agricultural goods. The supply-side driver arises from differences in sectoral productivity growth combined with complementarities between agriculture and non-agricultural goods (supply channel). Models incorporating one or both drivers/channels of structural change have widely been used in the literature,[2] but their applicability in the context of SSA is not known.

The analysis shows that despite the considerable differences in labour productivity across sectors[3], low productivity in agriculture and slow (negative) productivity growth in non-agriculture have reduced the pace of labour reallocation in SSA. Even in those countries that had

[2]See for example Duarte and Restuccia (2007), Duarte and Restuccia (2010), Dennis and İşcan (2009), İşcan (2011).

[3]For example, value added per worker in agriculture in Botswana is only 5.5% the size for services and 2.3% the size for industry in 2010. A similar pattern of sizeable sectoral productivity differences is observed in all countries even after adjusting for differences in human capital (by a factor of 1.5) and hours of work (by a factor of 1.2) as suggested by Gollin et al. (2011).

the fastest pace of structural change (Botswana, Mauritius, and South Africa), the rate of labour reallocation away from agriculture was slower than that of South Korea during a similar stage of its development. A quantitative assessment of the model shows that standard theories of structural change can account for about 50% of the change in the share of employment in agriculture and services in Botswana, Malawi, Mauritius, South Africa, and Zambia. Its explanatory power is weak for the rest of the countries, and in particular, fail to account for labour reallocation in agriculture or services in Ethiopia, Kenya, Nigeria, and Senegal. In manufacturing, the model explains about 60% of the change in the sector's employment share in only Mauritius and Nigeria and performs poorly for the rest of the sample: the total root means square error (RMSE) of the model for most countries is more than 20%. It thus suggests that standard models miss some fundamental elements of structural change in SSA and the lack of empirical evidence points to alternative or complementary explanations.

A further quantitative assessment based on a counter-factual analysis that replaces sectoral productivity growth rates in SSA with the corresponding growth rates for South Korea shows that raising productivity to levels seen in other rapidly growing economies is essential for accelerating the pace of labour reallocation in SSA. This counterfactual analysis indicates a more substantial decline in the share of employment in agriculture than those shown by the historical evidence. For example, in Zambia, the share of employment in agriculture would decline by 60% more than observed, and in Ethiopia and Tanzania, about 40% more than observed. In Botswana, Malawi, Nigeria, and Senegal the share of employment in agriculture would decline by 20% more than observed.[4] The results are also suggestive of a stronger role for agricultural productivity growth (i.e. agricultural-led) than non-agriculture (industrialization-led) in the transformation process. For example, a counter-factual analysis that replaces only agricultural productivity growth rates in SSA with the corresponding sectoral growth rates in South Korea indicates a relatively rapid labour reallocation away from agriculture than a counter-factual analysis replacing only productivity growth rates in industry.

The rest of the chapter is organized as follows. Section 2 provides a discussion of existing theories and the empirical literature on structural change. Section 3 presents the data and stylized facts on the pattern of labour reallocation and labour productivity in SSA. Section 4 presents the baseline model and section 5 assesses its quantitative implications for labour reallocation in SSA. Section 6 gives the concluding remarks. Technical and detailed data description are contained in appendix A.

## 2.2 Literature Review

This section reviews the theoretical and empirical literature. The first section presents the general overview of the theoretical framework and

[4]The Declines are even much stronger when the results are compared to the benchmark model-based series.

current debates. The second section reviews the related empirical literature on structural change, particularly, in the context of developing countries.

### 2.2.1 Theory

Economic growth and development are characterized by fundamental changes in the production and employment structure of the economy. These changes are commonly referred to as a structural change in the development literature and entail a secular decline in the shares of agriculture in total employment and aggregate income (Kuznets, 1957; Chenery, 1960; Kongsamut, Rebelo, and Xie, 2001; Ngai and Pissarides, 2007). While the traditional literature dates back to the 19th century, the pioneering work of Clark (1951), Kuznets (1957), and Chenery (1960) laid the theoretical foundation of contemporary work in this field. These authors argue that the dynamics of structural transformation in modern economies involve a massive and monotonic reallocation of labour from agriculture to manufacturing and services. This view, was, however, challenged by Maddison (1991) who argues that the process need not be monotonic. According to Maddison (1991) structural change involves three distinct phases: a monotonic decline in the share of employment in agriculture; a rise in the share of employment in services; a hump-shaped pattern in the share of employment in manufacturing. In recent years, there has been renewed interest in this field and considerable studies have been devoted to understanding this phenomenon (See Echevarria, 1997; Kongsamut et al., 2001; Duarte and Restuccia, 2007, 2010; Ngai and Pissarides, 2007; Acemoglu and Guerrieri, 2008; Buera and Kaboski, 2009; Dennis and İşcan, 2009, 2011; İşcan, 2011; Buera and Kaboski, 2012a; Uy, Yi, and Zhang, 2013; Üngör, 2013).

While there are likely to be many drivers of structural change, standard theories emphasize two complementary explanations: differential demand growth (demand-side drivers) and differential sectoral productivity growth (supply-side drivers). Though insightful, additional evidence from SSA is sparse and thus, the focus of this chapter.

### Demand-side Drivers of Structural Change (Engel Effect)

According to this channel, productivity growth in agriculture combined with a low income elasticity of demand for agricultural goods (due to non-homotheticity of preferences) can deliver structural change (Kongsamut et al., 2001; Foellmi and Zweimüller, 2008; Dennis and İşcan, 2009; Buera and Kaboski, 2012a). This channel requires that the income elasticity of demand for agricultural good be less than one and greater than unitary for non-agricultural good. The mechanism through which structural change occurs is as follows. As capital accumulation takes place and income rises, rising income level causes a relative shift in demand away from the good with a low-income elasticity of demand such as food towards the good with a high-income elasticity of demand (non-agriculture). Non-homotheticity is usually achieved by assuming preferences with subsistence constraint (e.g. Stone-Geary type preferences) or preferences that are hierarchical (Brown and Heien, 1972; Foellmi and Zweimüller, 2008). Hierarchical preferences not only allow for subsistence constraint but also permit the ranking of preferences based on some order of satisfaction.

### Supply-side Drivers of Structural Change (Baumol Effect)

According to this channel, structural change is the consequence of differential sectoral productivity growth combined with complementarities in demand between agriculture and non-agricultural goods. This channel requires differential productivity growth across sectors and elasticity of substitution less than unitary across sectors (see Baumol, 1967; Dennis and İşcan, 2009; Ngai and Pissarides, 2007). When the elasticity of substitution is less than one, faster productivity growth in agriculture relative to non-agriculture also leads to reallocation of labour away from agriculture to produce complementary non-agricultural goods. On the other hand, when the elasticity of substitution is greater than one, faster productivity growth in non-agriculture relative to agriculture also leads to labour reallocation away from agriculture. However, whether productivity growth in agriculture has been relatively faster than non-agriculture is an empirical matter. Alvarez-Cuadrado and Poschke (2011) makes this point using historical data for the United States.

Other complementary channels have been proposed but not explored in this study. For example, (Acemoglu and Guerrieri, 2008) emphasize sectoral differences in factor proportion and capital deepening. According to this channel, uneven sectoral productivity growth and differences in the rate of capital accumulation across sectors could lead to structural change and unbalanced growth path at the non-aggregate level. Thus, if there are differences in capital intensity across sectors, rapid capital deepening in agriculture increases the relative output of agriculture (capital-intensive sector) but also induces labour reallocation away from the same. Similarly, Alvarez-Cuadrado, Van Long, and Poschke (2017) have propose a complementary supply-side channel termed "factor rebalancing effect". When the degree of capital-labour substitutability differs across sectors, the more flexible sector uses the abundant input more intensively. Consequently, sectoral capital-labour ratios grow at different rates and the fractions of capital and labour allocated to sectors change over time. Other authors such as Ngai and Pissarides (2008), Rogerson (2008), and Buera and Kaboski (2012b), have also emphasized the substitutability/complementarity between home and market production and argue that the shift in labour market towards services could be the result of differential rates of productivity growth across the market and home production sectors.

### 2.2.2 Empirical Literature

#### Evidence from Industrialized and Newly Industrialized Countries

In the developed country context, several authors have studied the labour reallocation process using models that incorporate either the demand or supply channel or both channels. For example, Dennis and İşcan (2009) use an accounting framework to decompose labour reallocation in the United States into demand-side (Engel effect) and two supply-side (Baumol and capital deepening) effects, and show that the demand channel has been the dominant determinant of structural change in the United States. This channel accounts for almost the entire labour reallocation in the United States up until the 1950s. The Baumol effect only became relevant after 1950, and the capital deepening channel has been relatively weak. Similarly, using data on 12 industrialized countries from North America, Asia, and Europe, Alvarez-Cuadrado and Poschke (2011) evaluate the relative importance of demand-side (improvements in agricultural technology combined with Engel's law) and supply-side drivers (advancements in industrial technology) of structural change. Using a general equilibrium model that integrates both the demand and supply channels, they show that productivity improvement in non-agricultural sector (labour pull) has been the primary driver of the structural change prior to 1960, with productivity improvement in agriculture (labour push) only becoming important after 1960. Uy et al. (2013) extend the basic model to open economy to examine the impact of international trade on structural change. Their framework incorporates the demand and supply channels of structural change and a complementary trade channel. Using data on South Korea, they show that shock processes, propagated through non-homotheticity (demand channel) and the open economy (trade channel) could virtually account for the pattern of labour reallocation in South Korea. A further quantitative assessment shows that openness plays a vital role in explaining South Korea's structural change. The relative contribution of an open economy to the overall model fit (as indicated by the RMSE) is about 1/3; non-homothetic preferences contribution is 2/3. The authors further showed that while trade cost shocks are essential for the evolution of agriculture and manufacturing employment shares, non-homothetic preferences are essential for the evolution of services and agriculture employment shares.

### Evidence from Developing Countries: Asia and Latin America

In developing country context, majority of the studies are concentrated on Asia and Latin America. For example, Üngör (2013) studies a model that integrates only the demand channel of structural change. His model relates the share of employment in agriculture directly to subsistence requirement and inversely to agricultural productivity growth. He calibrates the model to several countries in Latin America and Asia and shows that productivity growth in agriculture alone can fully accounts for labour reallocation away from agriculture. Studies incorporating both channels of structural change have also been explored. Üngör (2017) explores the divergence in the structural transformation experience of Latin America and East Asia using a multi-sector general equilibrium model that features differential sectoral productivity growth and non-homothetic preferences. He finds that differences in within sectoral productivity growth between Latin America and East Asia account for much of the divergence in the structural transformation of the two regions. Świkecki (2017) also quantitatively assesses the relative importance of the demand, supply, and trade channels of structural change for the experience of Latin American and Asian countries. His study shows that while in developed countries, the supply channel propagated through biased sectoral productivity changes is critical for structural change, in developing countries, the demand channel propagated through nonhomothetic preferences is essential for labour reallocation out of agriculture. The effect of the trade channel for labour reallocation is less systematic than the demand and supply channels.

### Evidence from Developing Countries: Sub-Saharan Africa

In the SSA context, the evidence is sparse and less is known about the economic determinants of labour reallocation in SSA. Until recently, the issue has even been more pronounced due to the lack of quality and comparable data set. In general, many studies have emphasized agricultural productivity growth as the primary driver of structural change in SSA. For example, Restuccia, Yang, and Zhu (2008) argue that the large cross-country differences in employment share and labour productivity in agriculture are the consequence of barriers to modern inputs use in agriculture and labour market participation. Dennis and İşcan (2011) argue that the slow pace of structural change in developing countries including SSA is, in part due, to a development strategy that tax agriculture to mobilize resources for industrialization. McMillan and Rodrik (2011), on the other hand, blame the slow pace of structural transformation in SSA on "wrong" directional movement of labour, with labour moving from the more productive sectors to the less productive agricultural sector. The authors cite comparative advantage in primary products, rigid labour markets, and overvalued currencies as possible explanations for the misallocation of labour in SSA. McCaig, McMillan, Verduzco-Gallo, and Jefferis (2015), further argued that this pattern of labour misallocation appears to be particularly pronounced in Botswana. More recently, O'Gorman (2015) develop a general equilibrium framework to study the source of low labour productivity in agriculture and its implications for labour reallocation in SSA. Her study identified low government investment, low technology adoption, and inadequate factor endowments as the essential determinants of agricultural productivity and labour reallocation in SSA.

There is also growing evidence which demonstrates that slow productivity growth in non-agriculture and the region's inability to industrialized contributed to the slow pace of structural transformation observed in SSA. Page (2011), for example, blames the slow structural transofrmation in SSA on the lack of economic diversification and industrial sophistication. Using data on several African countries from 1975 to 2005, Page (2011) shows that the size, diversity, and level of sophistication of industries in many African countries have declined over the years and these account for the region's inability to industrialized and transform its agrarian economy.

The present study differs from the above studies in several respects. First, unlike studies that emphasize one or both channels of structural change and are primarily concentrated on developed, Asian or Latin American countries, this chapter focuses on labour reallocation in SSA. Also, unlike past studies on SSA that emphasize either productivity growth in agriculture or non-agriculture for structural change, the model developed in this chapter provides a unified framework to study labour reallocation in SSA. By incorporating both demand and supply channels, the model provides a framework to quantitatively assess the relative importance of sectoral productivity growth for labour reallocation in SSA.

## 2.3 Model, Data, and Calibration

This section presents a discussion on the model, data, and model calibration strategies. Section 1 derives the model. Section 2 presents the data and stylized facts on labour reallocation and economic growth in SSA. Section 3 presents the model calibration strategy.

### 2.3.1 The Baseline Model

To have a quantitative assessment of the pattern of productivity growth, structural change, and economic growth, the study uses a three-sector model with agriculture, industry (manufacturing), and services. The model incorporates two essential drivers of structural change: differential demand growth across sectors due to non-homothetic preferences (demand channel) and differential productivity growth across sectors (supply channel).[5]

#### Preferences

Preferences of the representative household are defined over consumption of agricultural goods ($c_{at}$), manufacturing goods ($c_{mt}$), and services ($c_{st}$)

$$\left[\gamma_a(c_{at} - \bar{c}_a)^{\frac{\varepsilon-1}{\varepsilon}} + \gamma_m(c_{mt})^{\frac{\varepsilon-1}{\varepsilon}} + \gamma_s(c_{st})^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{2.1}$$

[5] The model abstract from capital accumulation. While abstracting from the capital accumulation process closes the capital deepening channel of the structural change, its contribution to structural change per se is relatively weak, even for the United States (Dennis and İşcan, 2009). Also, capital is poorly measured in many developing countries compared to labour. Finally, most of the countries under consideration are highly agrarian-based economies producing mostly for subsistence consideration and using rudimentary technologies that are more labour intensive than capital (see chapter 3)

where $\bar{c_a} > 0$ is the subsistence level of consumption of agricultural good (food); $\gamma_i$ denote sectoral consumption/expenditure shares; and $\varepsilon > 0$ is the elasticity of substitution. Setting $\bar{c_m} = \bar{c_s} = 0$ but allow for a positive subsistence level of consumption of agricultural good is standard in the literature (see for example Buera and Kaboski, 2009; Dennis and İşcan, 2009; Świkecki, 2017; Üngör, 2017) and fits the development experience of many developing countries. In SSA, productivity level in agriculture is low; many farming households produce close to subsistence. Yet, farming households must consume a certain amount of food (subsistence requirement) for survival. Therefore, the Engel effect acting through subsistence requirement would be a relevant channel for structural change in these economies. The representative household solves a sequence of intratemporal consumption allocation problem subject to the budget constraint

$$\sum_{i=a,m,s} p_{it} c_{it} \leq w_t, \tag{2.2}$$

and given output prices $(p_{i,t})$ and household income $w_t$.

### Production

The final output in sector $i$ is determined as

$$Y_{it} = A_{it} L_{it}, \tag{2.3}$$

where $A_{it} > 0$ is the sector-specific productivity term at time $t$ and $L_{it}$ is the labour employment in sector $i$ at time $t$. All sectors produce final consumption good, thus, $Y_{it} = A_{it}L_{it} = c_{it}$. There is also perfect factor mobility across sectors. The allocation of labour across sectors at any point in time satisfies the aggregate resource constraint

$$L_{at} + L_{mt} + L_{st} = 1, \tag{2.4}$$

so that $L_{it}$ is also the share of employment in sector $i$ at time $t$.[6]

### Optimality Conditions

The representative firm solves a similar intratemporal allocation problem to maximize profit, taking as given the prices of output and inputs. The allocation of labour across sectors requires that the value of marginal product of labour ($VMPL$) be equalized across sectors

$$VMPL_a = VMPL_m = VMPL_s. \tag{2.5}$$

Thus, we have

$$p_a A_a = p_m A_m = p_s A_s.$$

Setting the price of manufacturing good as the numeraire, the relative

[6]Due to CRS, the use of employment shares and size of labour force is not consequential.

price of agriculture and services are respectively determined as

$$p_a = \frac{A_m}{A_a} \text{ and } p_s = \frac{A_m}{A_s}. \tag{2.6}$$

The first-order conditions of the representative household utility maximization problem yield the following optimality conditions

$$p_a^{\varepsilon} = \left(\frac{\gamma_a}{\gamma_m}\right)^{\varepsilon} \left(\frac{c_{mt}}{c_{at} - \bar{c}_a}\right), \tag{2.7}$$

$$p_s^{\varepsilon} = \left(\frac{\gamma_s}{\gamma_m}\right)^{\varepsilon} \left(\frac{c_{mt}}{c_{st}}\right). \tag{2.8}$$

From equations (2.7) and (2.8), $c_{at}$ and $c_{st}$ are determined as

$$c_{at} = \left(\frac{\gamma_a}{\gamma_m}\right)^{\varepsilon} p_a^{-\varepsilon} c_{mt} + \bar{c}_a,$$

$$c_{st} = \left(\frac{\gamma_s}{\gamma_m}\right)^{\varepsilon} p_s^{-\varepsilon} c_{mt}.$$

**Equilibrium Sectoral Labour Allocation**

Using the condition that all sectors produce final consumption goods such such that $c_{it} = Y_{it}$, the equilibrium allocation of labour in agriculture and services are determined as

$$L_a = \left(\frac{\gamma_a}{\gamma_m}\right)^{\varepsilon} p_a^{1-\varepsilon} L_m + \frac{\bar{c_a}}{A_a}, \tag{2.9}$$

$$L_s = \left(\frac{\gamma_s}{\gamma_m}\right)^{\varepsilon} p_s^{1-\varepsilon} L_m. \tag{2.10}$$

Combining equations (2.9) and (2.10), and the labour resource constraint from equation (2.4) yield employment in manufacturing as

$$L_m = \frac{1 - \frac{\bar{c_a}}{A_a}}{1 + \left(\frac{\gamma_a}{\gamma_m}\right)^{\varepsilon} p_a^{1-\varepsilon} + \left(\frac{\gamma_s}{\gamma_m}\right)^{\varepsilon} p_s^{1-\varepsilon}}, \tag{2.11}$$

$$L_m = \frac{1 - \Gamma(A)}{1 + \varphi(A)}. \tag{2.12}$$

1. The differential income elasticity of demand effect is determined by the term

$$\Gamma(A) = \frac{\bar{c_a}}{A_a}. \tag{2.13}$$

   It captures the demand-side driver (Engel effect) of structural change acting through non-homothetic preferences. It is determined as the ratio of the subsistence consumption requirement $\bar{c_a}$ to productivity (growth) in agriculture. Rising productivity in agriculture raises income and food consumption. However, the presence of subsistence consumption in agriculture gives rise to low elasticity of demand for agricultural good (food). Hence, the increase in demand for food is proportionately less than the rise in aggregate income. Moreover, with rising productivity in agriculture, the increase in demand for food can now be produce with less labour requirement. Subsequently, labour reallocates away from agriculture to non-agriculture.

2. The differential sectoral productivity growth effect is given by the term

$$\varphi(A) = \left(\frac{\gamma_a}{\gamma_m}\right)^{\varepsilon}\left(\frac{A_m}{A_a}\right)^{1-\varepsilon} + \left(\frac{\gamma_s}{\gamma_m}\right)^{\varepsilon}\left(\frac{A_m}{A_s}\right)^{1-\varepsilon}. \tag{2.14}$$

It captures the supply-side driver (Baumol effect) of structural change acting through differences in productivity growth across sectors. Equation (2.14) shows that the effect of rising productivity on labour reallocation depends on the demand elasticity of substitution across final goods. If productivity in agriculture rises faster relative to non-agriculture, when the elasticity of substitution is unitary (i.e. $\varepsilon = 1$), the differential sectoral productivity growth effect disappears regardless of the magnitude of the differences in productivity growth across sectors. Labour reallocation is thus driven solely by the demand forces. When the elasticity of substitution is less than unitary (i.e. $\varepsilon < 1$), there is gross complementarities in demand and faster productivity growth in agriculture also leads to reallocation of labour away from the same. On the other hand, when the elasticity of substitution is greater than unitary (i.e. $\varepsilon > 1$), there is gross substitutability in demand and faster productivity growth in non-agriculture (industry or services) leads to labour reallocation away from agriculture.

### 2.3.2 Data and Stylized Facts on Structural Change and Economic Growth in SSA

#### *Data Source*

The data are obtained from the 10-Sector Database published by the Groningen Growth and Development Centre (GGDC) and is described in Timmer, de Vries, and de Vries (2015). The database provides data on employment and value-added (in current and constant national prices), disaggregated into ten economic sectors for a panel of 41 countries. They consist of nine Latin American, 10 Asian, eight European, one North American (United States), 11 SSA and two North African countries. This database is the first to provide long-term series on sectoral developments, especially, on Africa. The data is constructed through an extensive study of available statistical sources on a country-by-country basis. Value-added data in constant 2005 local, national prices are converted into a common currency using the 2005 Purchasing Power Parity (PPP) US dollars to aid in productivity comparison between sectors and across countries. The PPP exchange rates are obtained from the Pen World Table (PWT) version 8.1 (latest version PWT 9.0) and are the economy-wide PPP since sector-specific PPPs are not available for all countries. This dataset is compiled by Feenstra, Inklaar, and Timmer (2015). The final sample comprises 11 SSA countries: Botswana, Ethiopia, Ghana, Kenya, Malawi, Mauritius, Nigeria, Senegal, South Africa, Tanzania, and Zambia, and spans from 1970 to

Table 2.1: Sector coverage, major divisions and sectors classification

| Sector | ISIC Rev. 2 | ISIC Rev. 3 | Sector |
|---|---|---|---|
| Agriculture, Hunting, Forestry & Fishing | Major Division 1 | A+B | Agriculture |
| Mining & Quarrying | Major Division 2 | C | Industry |
| Manufacturing | Major Division 3 | D | Industry |
| Electricity, Gas & Water Supply | Major Division 4 | E | Industry |
| Construction | Major Division 5 | F | Industry |
| Wholesale and Retail Trade, Hotels & Restaurants | Major Division 6 | G+H | Services |
| Transport, Storage, & Communication | Major Division 7 | I | Services |
| Finance, Insurance, Real Estate & Business Services | Major Division 8 | J+K | Services |
| Government Services | Major Division 9 | L+M+N | Services |
| Community, Social & Personal Services | Major Division 10 | O+P | Services |

Source: Timmer and de Vries (2007, 2009). ISIC Rev. 2 and Rev. 3 definitions refer to the second and third major revisions of the International Standard Industry Classification (ISIC)

2010. For comparison purpose, the study also includes data on South Korea.

The study also supplements the analysis with data from the Food and Agriculture Organization (FAO), UNdata, and the World Bank World Development Indicators (WDI). All three databases provide similar data on employment and aggregate value added. The WDI and UNData databases contain data on employment and value added by broad economic sectors. The FAO provides similar data but only for the agricultural sector. Although these databases vary in their methodological approach, they, nevertheless, provide consistent estimates of aggregate variables such as employment and value added. For example, the correlation between the GGDC data and the FAO data for the share of employment in agriculture is high in most countries (see appendix A). The correlation for the case of Nigeria is, however, surprising low and for Zambia appears negative.[7] Next, the 10-Sectors are aggregated into

[7]Factors that could be responsible for this observation are differences in methodology concerning

three major sectors: agriculture, industry, and services. Agriculture includes hunting, forestry, and fishing. Table 2.1 gives the breakdown of the ten economic sectors included in the three broad sectors, agriculture, industry, and services. A detailed breakdown of each sub-sector by economic activity is provided in Appendix A.

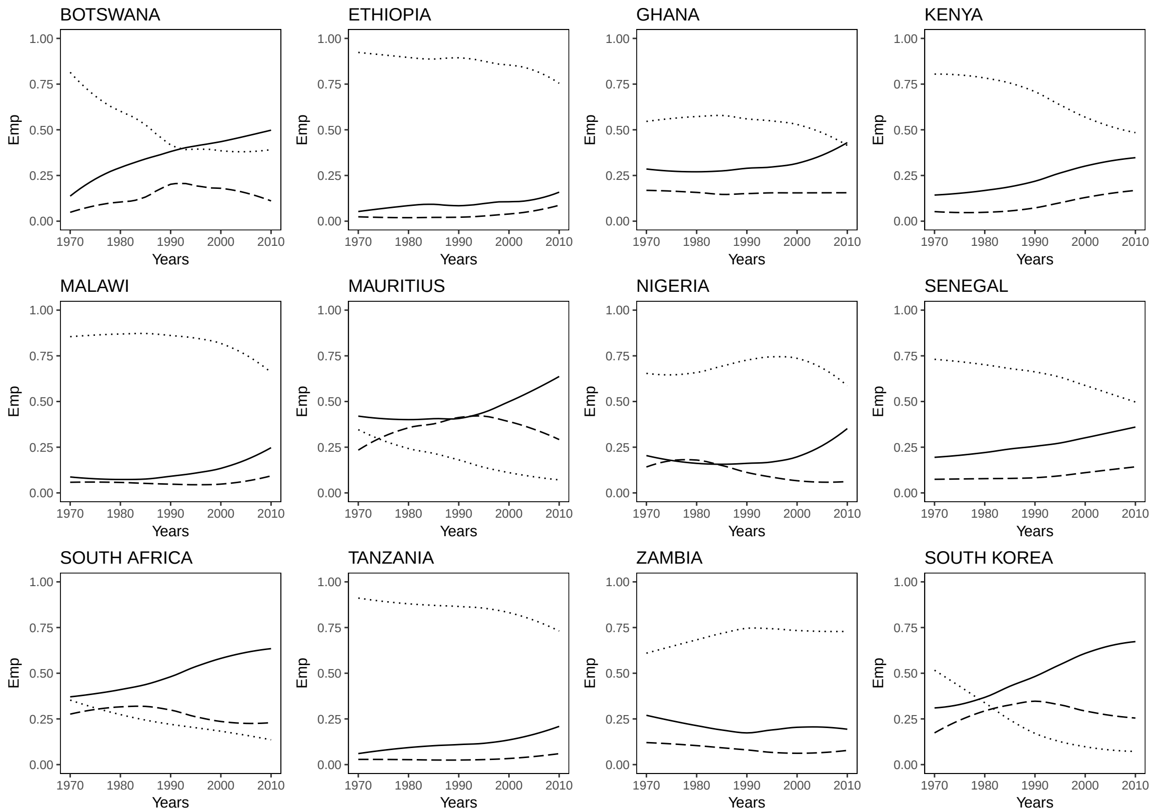
### *Sectoral Employment and Value-Added Shares*

The two established observations consistent with structural change are 1) a secular decline in the share of employment in agriculture and; 2) a decline in the share of agriculture in aggregate income. Figure 2.1 shows the share of employment in agriculture, industry (manufacturing), and services for the 11 SSA countries and South Korea from 1970 to 2010.

The figure shows that structural change is a common phenomenon even in SSA. With the possible exception of Zambia, all countries in the sample experienced a systematic decline in the share of employment in agriculture and a rise in the share of employment in non-agriculture. For example, in 1970 the share of employment in agriculture was approximately 92% in Ethiopia, 83% in Botswana, 81% in Kenya, and 57% in Ghana. By the end of 2010, agriculture accounted for about 75% of employment in Ethiopia, 39% in Botswana, 48% in Kenya, and 42% in Ghana. Over the same period, there was a significant rise in the share of employment in services in these countries. In Botswana, the share of services in total employment rose from 13% in 1970 to about

aggregation and accounting for missing data points, and differences in the quality of data. Data quality is one of the problems highlighted by De Vries, Timmer, and De Vries (2013).

Figure 2.1: The share of employment in agriculture, industry (manufacturing), and services

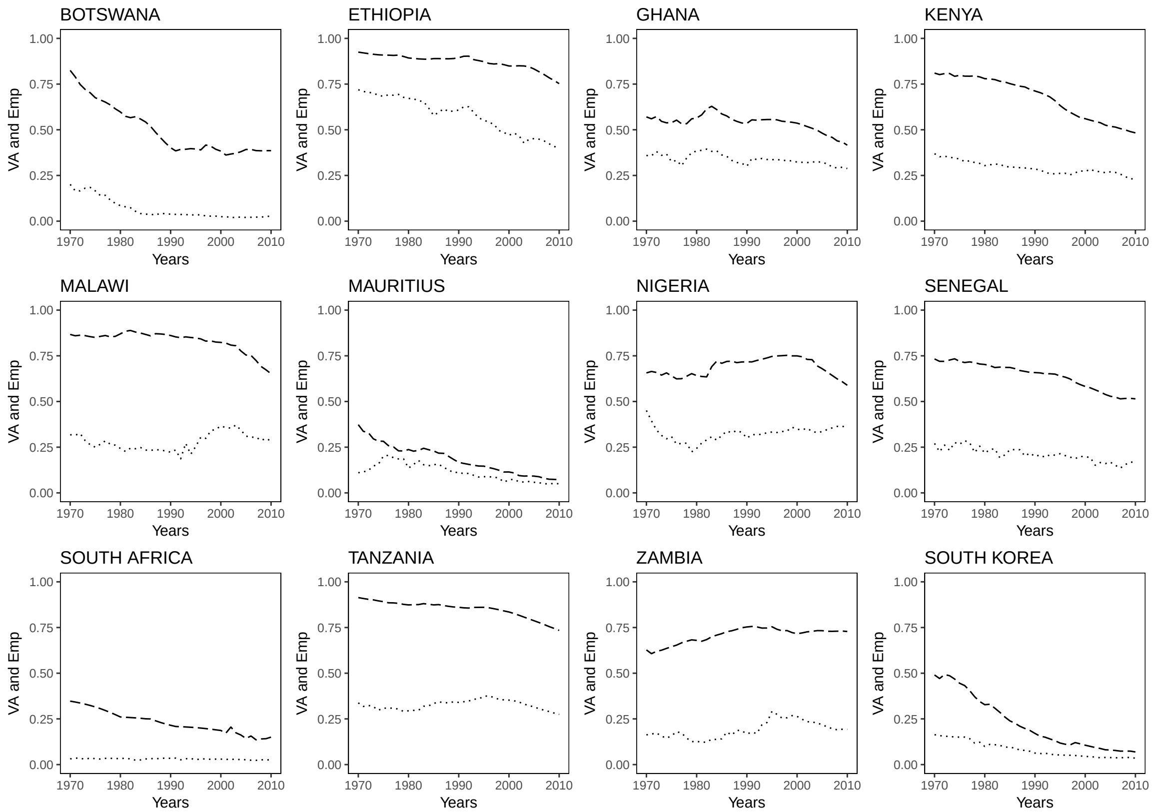



Note: The share of employment in agriculture is denoted by the dotted (...), industry (manufacturing) by dashed (- - -) and services by the solid (—) lines.
Source: Data is from the 10-Sector Database published by GGDC for the period 1970-2010.

50% in 2010. In Zambia, by contrast, the share of agriculture in total employment rose from 63% to 73% while the share of services declined from 26% to 20% over the same period.

The figure also reveals striking observations employment in industry over the past 40 years. The share of industry in total employment declined in Zambia, remained relatively stable in Ghana and Tanzania, and rose marginally in Ethiopia, Kenya, Malawi, and Senegal. By contrast, it rose sharply in Botswana, Nigeria, Mauritius, and South Africa

Figure 2.2: The share of employment and value added in agriculture




Note: The share of employment and value-added in agriculture are denoted by the dashed (- - -) and dotted (...) lines respectively.
Source: Data is from the 10-Sector database published by GGDC for the period 1970-2010.

at early stages of their development. A similar pattern of a sharp rise in the share of industry in total employment at early stages of development is observed in South Korea as well. However, whereas as in South Korea, industry continues to accounts for significant share in total employment (about 27% in total employment), Botswana and Nigeria experienced what many authors described as early de-industrialization. In Nigeria, for example, the share of employment in industry rose from about 14% in 1970, peaked at 21% by early 1980s and sharply declined to about 6% by 2010. A similar pattern is observed in Botswana where the share of employment in industry rose from 4% in 1970, peaked at 23% in the early 1990s and thereafter declined steadily to about 11% by 2010. It is also worth emphasizing that even though the share of employment in industry in many countries in SSA rose over the period, it never reached the level observed in South Korea. The only possible exception is Mauritius.

Figure 2.2 plots the share of employment in agriculture and the share of agriculture in total value-added from 1970 to 2010. The figure shows that, with the exception of Zambia, all countries experienced a systematic decline in the share of agriculture in total value-added for the period under consideration. In Botswana, the share of agriculture in total value-added declined from 20% to 3%. In Ethiopia, it fell from 72% to 40%, and in Kenya from 37% to 23%. By contrast, in Zambia, it rose from 16% in 1970 to about 20% in 2010. Also, comparing these two measures, the following observations emerge. First, economic theory predicts that in the absence of differences in human capital and factor distortions, the share of employment in agriculture and agriculture's share in total value added should be similar. Second, to the extent that these two differ, such disparities should decline over time if differences in human capital and factor distortions across sectors disappear (Buera and Kaboski, 2009).[8] However, as is evident from Figure 2.2, this has not been the case in many SSA countries. In fact, except for Mauritius and South Africa, none of the countries has exhibited any of

[8]It must, however, be noted that if sectors produce an intermediate, as well as final goods, employment and value-added share, can be different from one another.

form convergence.

To have a quantitative assessment of the pace of structural change in SSA, Table 2.2 presents the change in the share of employment in agriculture and the share of agriculture in total value-added between 1970 and 2010. The analysis shows a slower pace of structural change for many countries in SSA. Nonetheless, the following observations are worth noting.

1. There is heterogeneity in the pace of structural change within the SSA sample. The evidence shows that structural change has not been uniformly slow in all countries. Whereas the pace of labour reallocation away from agriculture has been rapid in Botswana, Mauritius, and South Africa, it has been remarkably slow in countries such as Ethiopia, Ghana, Malawi, Nigeria, Senegal, Tanzania, and Zambia. For example, the share of agriculture in total employment declined by over 50% in Botswana, Mauritius, and South Africa compared to about 10% in Nigeria, 18% in Ethiopia, and 20% in Tanzania. In Zambia, by contrast, the share of agriculture in total employment rose by about 16%.

2. Even in those countries that had rapid structural change (Botswana, Mauritius and South Africa), the rate of labour reallocation out of agriculture is much slower than that of South Korea at a similar stage of development. As an example, around 1970 South Korea had about half of its labour force employed in agriculture; similar

Table 2.2: Changes in the share of employment and value added in agriculture

| Country | Employment | | Value Added | |
|---|---|---|---|---|
| | Absolute Δ | Percent Δ | Absolute Δ | Percent Δ |
| Botswana | -44 | -53.24 | -17 | -86.57 |
| Ethiopia | -17 | -18.65 | -32 | -44.55 |
| Ghana | -15 | -27.14 | -07 | -19.85 |
| Kenya | -33 | -40.38 | -14 | -36.96 |
| Malawi | -22 | -24.82 | -03 | -10.76 |
| Mauritius | -30 | -80.80 | -06 | -55.08 |
| Nigeria | -07 | -10.28 | -09 | -20.27 |
| Senegal | -22 | -29.80 | -10 | -37.53 |
| South Africa | -20 | -56.72 | -01 | -18.46 |
| Tanzania | -18 | -19.65 | -06 | -18.73 |
| Zambia | 10 | 16.05 | 03 | 18.52 |
| South Korea | -42 | -85.92 | -13 | -78.73 |

Source: Author's calculation based on data from the 10-Sector database published by GGDC for the period 1970-2010.

to many SSA countries. However, four decades later, this sector accounts for less than 7% of the total employment; a decline of about 86%.[9]

In concluding, the analysis shows that structural change is a common phenomenon even in SSA. There is, however, a considerable cross-country heterogeneity in the pace of structural change (labour reallocation). Overall, the process has been remarkably slow in many countries in SSA. The share of employment in agriculture remains high in most

[9]Within the latter group of SSA countries, only Mauritius's pace of labour reallocation away from agriculture is comparable to that of South Korea. Even though Botswana experienced a rapid structural change in the early 1970s and 1990s with the share of employment in agriculture declining from over 80 % to a little below 40%, this has slowed down in recent years

countries in SSA, with agriculture accounting for over 50% of total employment in countries such as Ethiopia, Kenya, Malawi, Nigeria, Senegal, Tanzania, and Zambia. Also, even in those countries that had a faster pace of structural change such as Botswana and Mauritius, the rate of labour reallocation away from agriculture to industry has been slower than that of South Korea during a similar stage of its development.

### *Sectoral Labour Productivity*

Sectoral labour productivity growth is a crucial ingredient for both the demand-side and supply-side drivers of structural change. Sectoral labour productivity (i.e. output per worker) is calculated by dividing each country's sectoral value-added by the corresponding sectoral level of employment. Table 2.3 reports the annualized labour productivity growth (calculated as the percentage change in labour productivity between 1970 and 2010) for agriculture, industry, and services. The table also reports the labour productivity levels for 2010, converted into a common currency using the 2005 PPP US dollars. The reported estimates have not been adjusted for differences in hours worked or human capital across sectors; adjusting for these differences do not in anyway change the overall conclusion of the paper.

The analysis indicates a substantial disparity in labour productivity across sectors and countries. A within-country comparison shows that agriculture has the lowest labour productivity in all the countries. Labour productivity is highest for services in Ethiopia, Kenya, Mauritius, and Senegal. In Botswana, Ghana, Malawi, Nigeria, South Africa, Tanzania, and Zambia, labour productivity is highest in industry. For example, in Botswana, labour productivity in agriculture is about 2.4% the size of industry, where industry includes mining and construction. In Nigeria, it is about 11% the size of industry, and in South Africa, Tanzania, and Zambia, about 13%, 9%, and 7% respectively. The high labour productivity levels in industry in Botswana, Nigeria, South Africa, and Zambia, are in part driven by the strong performance of the mining sector. These countries are natural resource abundant and labour productivity in mining is generally high due to its high capital intensity.

A comparison across country-sector pairs shows that labour productivity in agriculture is the lowest for Malawi ($1,025) and highest for Mauritius ($19,577). Labour productivity in agriculture is about 20 times higher in Mauritius than in Malawi. In industry, labour productivity is the highest for Botswana ($100,986) and the lowest for Ethiopia ($2,956). Thus, labour productivity in industry in Ethiopia is about 2.8% the size in Botswana. In services, labour productivity is the highest in Botswana ($42,724) and the lowest in Malawi ($4,809). However, when compared to South Korea, agricultural and aggregate labour productivity in most SSA countries lag behind those of South Korea, even

Table 2.3: Sectoral labour productivity level and growth

| | Labour Productivity Growth | | | | Labour Productivity Level | | | |
|---|---|---|---|---|---|---|---|---|
| Country | Agr. | Ind. | Ser. | Agg | Agr. | Ind. | Ser | Agg |
| Botswana | 1.76 | 2.14 | 2.64 | 4.88 | 2,367 | 100,986 | 42,724 | 33,820 |
| Ethiopia | -0.28 | -1.83 | 0.15 | 0.67 | 1,110 | 2,956 | 6,270 | 2,094 |
| Ghana | 0.67 | -0.56 | 0.47 | 0.43 | 4,296 | 8,793 | 7,116 | 6,201 |
| Kenya | 0.06 | -2.72 | -1.84 | -0.08 | 1,883 | 4,714 | 6,306 | 3,909 |
| Malawi | 1.50 | -0.06 | -1.80 | 1.07 | 1,025 | 4,933 | 4,809 | 2,354 |
| Mauritius | 5.41 | 2.42 | 2.50 | 3.29 | 19,577 | 25,247 | 30,843 | 28,341 |
| Nigeria | 0.93 | 2.69 | 2.35 | 1.22 | 4,238 | 39,225 | 5,952 | 6,942 |
| Senegal | -1.15 | -1.89 | -2.07 | -0.85 | 1,582 | 7,866 | 8,392 | 4,815 |
| South Africa | 2.58 | 0.59 | 0.31 | 1.00 | 5,194 | 40,565 | 33,434 | 30,748 |
| Tanzania | 1.20 | -0.79 | -1.63 | 1.17 | 1,108 | 12,071 | 6,941 | 2,965 |
| Zambia | 0.45 | -0.03 | 2.45 | 0.40 | 1,454 | 21,937 | 14,182 | 5,492 |
| South Korea | 4.54 | 5.06 | 1.06 | 3.51 | 22,882 | 78,180 | 34,666 | 45,392 |

Note: Labour productivity is defined as value-added per worker. Level is for 2010 expressed in constant 2005 PPP US dollars and unadjusted for differences in human capital and hours worked across sectors.
Source: Data is from the 10-Sector Database published by GGDC for the period 1970-2010.

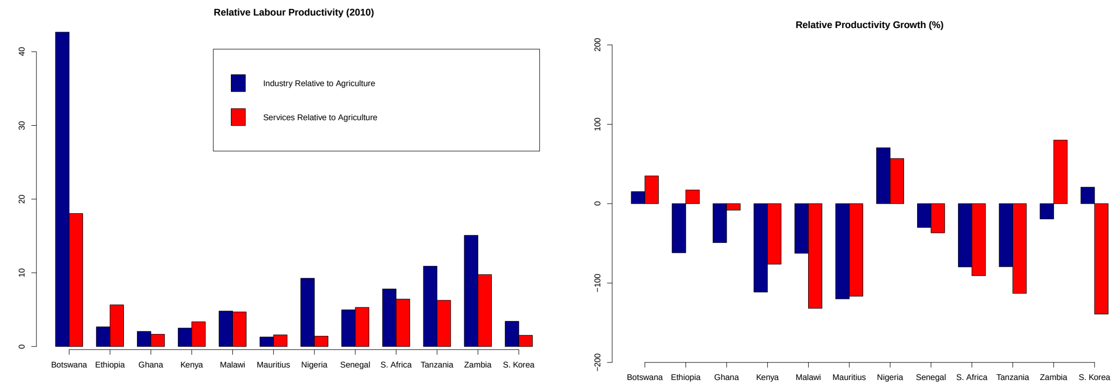
for Botswana, Mauritius, and South Africa. For example, the aggregate labour productivity in Ethiopia, Malawi, Tanzania, and Kenya are about 10% the size of South Korea, and in Botswana, Mauritius, and South Africa about 70%. At the sector-level, except in Botswana, labour productivity is significantly higher in all sectors in South Korea than any country in SSA. In Botswana, labour productivity is higher in industry and services than those of South Korea.

The analysis also reveals striking differences in labour productivity growth across sectors and countries over the same period. First, the analysis shows that growth in aggregate labour productivity has been remarkably slow in many countries in SSA; even negative in Kenya and

Senegal. A further comparison indicates that the growth in aggregate labour productivity is the strongest for Botswana, with an annualized growth rate of 4.9% and the weakest for Senegal with an annualized growth rate of -0.85%. Second, a country-sector pair comparison shows that labour productivity growth in agriculture is the highest for Mauritius (with an annualized growth rate of 5.4%) and lowest for Senegal (with an annualized growth rate of -1.15%). In industry, it is the strongest for Nigeria (2.69%) and the weakest for Senegal (-1.89%), and in services, it is the strongest for Botswana (2.64%) and weakest for Senegal (-2.07%). However, when compared to South Korea, growth in labour productivity in most SSA countries rank behind those of South Korea, even for some of the fast-growing economies in SSA. Third, a within-country comparison shows that despite the low labour productivity in agriculture, labour productivity growth in agriculture dominates those of industry and services in most countries. Productivity growth in industry (notably, manufacturing) has been particularly weak, with countries such as Ethiopia, Ghana, Kenya, Malawi, Senegal, Tanzania, and Zambia recording negative growth over this period.

Figure 2.3 Panel A presents the labour productivity in industry and services relative to agriculture. The analysis indicates a substantial disparity in relative labour productivity between sectors and across countries. The relative labour productivity is much higher in industry than in services in most countries, and particularly more pronounced in the resource-abundant countries such as Botswana, Nigeria, South Africa,

Figure 2.3: Relative labour productivity in industry and services




(a) Labour productivity in industry and services relative to agriculture

(b) Changes in relative labour productivity

Source: Data is from the 10-Sector Database published by GGDC for the period 1970 to 2010.

Tanzania, and Zambia. For example, the relative labour productivity in industry is 43 in Botswana, 14 in Tanzania, and 11 in Zambia compared to one in Mauritius and three in Kenya. A further comparison across country-sector pairs shows that relative labour productivity in industry is the lowest in Mauritius and the highest in Botswana. In services, it is the lowest in Nigeria and highest in Botswana.

Figure 2.3 panel B shows the changes in relative labour productivity for industry and services between 1970 and 2010. The analysis shows stronger convergence in relative labour productivity for most countries in SSA. There is a significant decline in the labour productivity gap, particularly in industry, declining by over 40% in Ethiopia, Ghana, Kenya, Malawi, Mauritius, South Africa, and Tanzania. In Botswana, Ethiopia, Nigeria, and Zambia, however, the labour productivity gap in industry widened over this period. A similar pattern of strong convergence in sectoral labour productivity is observed in services as well in most countries. The only exceptions are Botswana, Ethiopia, and Zambia. However, the strong convergence in labour productivity, is on average, due to initially high productivity sectors exhibiting negative productivity growth rather than low productivity sectors exhibiting rapid productivity growth. This pattern can be seen in countries such as Ethiopia, Ghana, Kenya, Malawi, Senegal, Tanzania, and Zambia. For example, the labour productivity in agriculture relative to industry declined from 8 to 3 in Kenya and from 24 to 11 in Tanzania between 1970 and 2010. In services, it decreased from 7 to 3 in Kenya and 19 to 6 in Tanzania. However, over the same period, labour productivity in industry grew at an annualized rate of -2.72% in Kenya and -0.80% in Tanzania, and in services at a rate of -1.84% in Kenya and -1.63% in Tanzania. The only countries that had convergence in the real sense are Mauritius and South Africa where labour productivity growth in agriculture was much stronger than in services and industry.

In summary, the analysis indicates considerable differences in labour productivity between sectors and across country-sector pairs. Labour productivity is relatively low in agriculture than in industry or services, and the relative labour productivity gap is more pronounced in industry than in services. While there appears to be convergence in sectoral labour productivity, the convergence is due to initially high productivity sectors exhibiting negative growth rather than low productivity sectors

Table 2.4: Changes in the share of employment in agriculture and per capita GDP growth

| | Agriculture | | GDP per capita | Correlation |
|---|---|---|---|---|
| Country | Absolute Δ | Percentage | Annualized growth | coefficients |
| Botswana | -0.44 | -53.2 | 4.99 | -0.94 |
| Ethiopia | -0.17 | -18.6 | 1.13 | -0.69 |
| Ghana | -0.15 | -27.1 | 0.75 | -0.86 |
| Kenya | -0.33 | -40.4 | 0.55 | -0.53 |
| Malawi | -0.22 | -24.8 | 1.22 | -0.63 |
| Mauritius | -0.30 | -80.8 | 3.99 | -0.95 |
| Nigeria | -0.07 | -10.3 | 1.35 | -0.72 |
| Senegal | -0.22 | -29.8 | 0.12 | -0.36 |
| South Africa | -0.20 | -56.7 | 0.57 | -0.21 |
| Tanzania | -0.18 | -19.6 | 0.87 | -0.71 |
| Zambia | 0.10 | 16.1 | -0.75 | -0.87 |
| South Korea | -0.42 | -85.9 | 5.76 | -0.89 |

Source: Author's calculations based on the 10-Sector database published by GGDC for the period 1970-2010.

exhibiting rapid productivity growth.

### ***Structural Change and Economic Growth***

To have an assessment of the relationship between the pattern of labour reallocation and economic growth in SSA, Table 2.4 present the correlation between changes in the share of employment in agriculture and the growth in real GDP per capita. The analysis indicates a strong negative correlation between structural change (labour reallocation) and GDP per capita growth. This is particularly strong for countries with rapid labour reallocation such as Botswana and Mauritius. Both Botswana and Mauritius experienced rapid structural change, with the share of labour in agriculture declining by over 50% between 1970 and 2010. Over the same period, real GDP per capita grew at an annualized rate of about 5% in Botswana and 4% in Mauritius. By contrast, despite the rapid labour reallocation in South Africa, the annualized growth in GDP per capita was less than 1%. Zambia is one country that appears to have reallocated labour in the "wrong" direction; the share of employment in agriculture increased by almost 20%. Over the same period, the annualized growth in GDP per capita was negative (-0.75%) and the correlation coefficient was -0.87. Also, Ghana, Kenya, and Senegal had a moderate labour reallocation and growth in real GDP per capita was slow. By contrast, Ethiopia, Malawi, and Nigeria had a slow pace of structural change, yet the annualized growth in real GDP per capita was higher than the former group.

Therefore, to have a further quantitative assessment of the pace of labour reallocation and sectoral productivity growth, and the relative contributions of each component to economic growth, the study uses a data-driven decomposition analysis. The model decompose growth in aggregate labour productivity into "within" and "between" components. The "within" component is the consequence of technological progress, increased efficiency or reduced misallocation within a particular sector. Growth resulting from "between" (structural change) is the result of labour reallocation from low productivity sectors to high productivity sectors. This approach to studying the relationship between labour reallocation (structural change) and economic growth has been

Table 2.5: Regional-level labour productivity growth decomposition analysis

| Measure | Within | Between | Overall |
|---|---|---|---|
| Weighted average labour productivity growth rate | 0.41 | 0.17 | 0.58 |
| Simple average labour productivity growth rate | 0.54 | 0.65 | 1.19 |

Source: Author's calculations based on the 10-Sector database for the period 1970-2010.

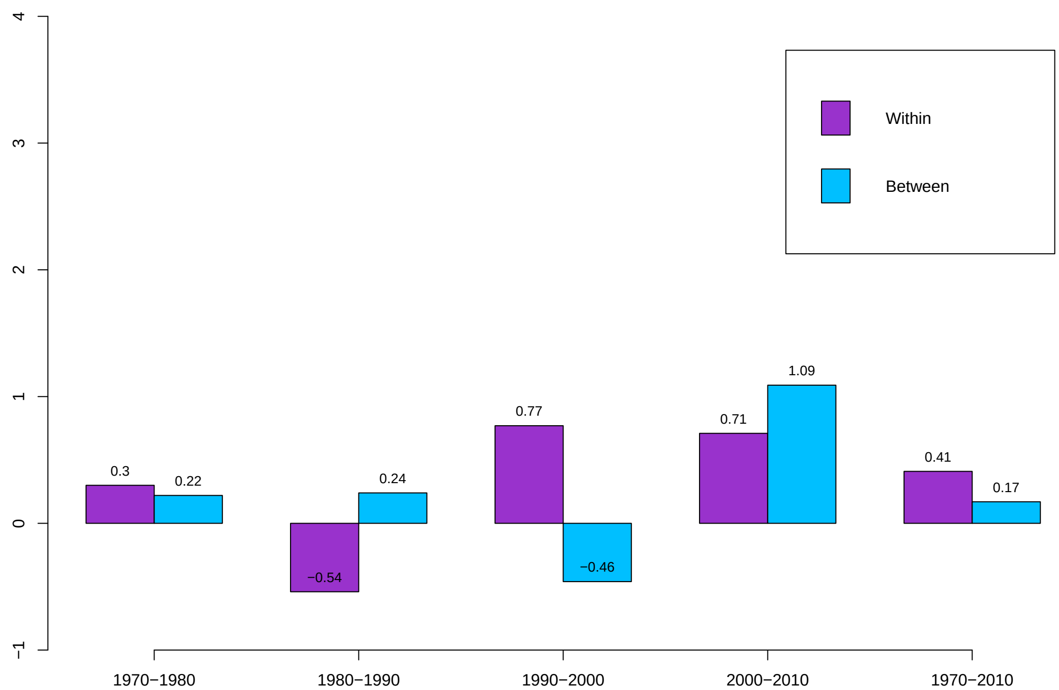
widely used in the literature (see for example McMillan and Rodrik (2011)). The growth in aggregate labour productivity is decomposed as

$$\Delta Y_t = \underbrace{\sum_{i=n} \theta_{i,t-k} \Delta y_{i,t}}_{\text{within}} + \underbrace{\sum_{i=n} y_{i,t} \Delta \theta_{i,t}}_{\text{between}}, \tag{2.15}$$

where $Y_t$ and $y_{i,t}$ are respectively the aggregate and sectoral labour productivity levels at year $t$, $\theta_{i,t}$ is the share of employment in sector $i$ and $\Delta$ denotes the change in labour productivity or the share of employment in sector $i's$ between year $t$ and $t-k$. Equation (2.15) thus expresses the change in aggregate labour productivity as the weighted sum of the within-sector productivity growth and structural change (labour reallocation) effect.

Table 2.5 presents the result of the regional decomposition analysis. The estimates reported are based on simple (unweighted) and weighted averages across the sample. The un-weighted average estimate is simply the arithmetic mean of the individual country-level estimates. The weighted average, by contrast, first sums across country-sector pairs

Figure 2.4: Decomposition of labour productivity growth into "between" and "within"




Source: Author's calculations based on the 10-Sector database for the period 1970-2010.

value-added (in 2005 PPP US dollars) and labour employment. Aggregate and sector-specific labour productivity measures are calculated, and growth in aggregate productivity decomposed into within and between components.

The analysis shows a small but positive contribution of structural change (labour reallocation) to economic growth. Between 1970 and 2010, aggregate labour productivity in SSA grew at an annualized rate of 0.58%, and the contribution of between (structural change) was

Table 2.6: Country-level decomposition of labour productivity growth

| | Low productivity growth countries | | |
|---|---|---|---|
| Country | Within | Between | Overall |
| Ethiopia | -0.21 | 0.88 | 0.67 |
| Ghana | 0.23 | 0.20 | 0.43 |
| Kenya | -0.75 | 0.67 | -0.08 |
| Malawi | 0.11 | 0.96 | 1.07 |
| Nigeria | 1.50 | -0.28 | 1.22 |
| Senegal | -1.09 | 0.23 | -0.85 |
| South Africa | 0.69 | 0.31 | 1.00 |
| Tanzania | 0.09 | 1.07 | 1.17 |
| Zambia | 0.85 | -0.56 | 0.29 |
| | High productivity growth countries | | |
| Country | Within | Between | Overall |
| Botswana | 1.91 | 2.97 | 4.88 |
| Mauritius | 2.54 | 0.75 | 3.29 |
| South Korea | 2.82 | 0.69 | 3.51 |

Source: Author's calculation based on the 10-Sector database published by GGDC for the period 1970-2010.

about 0.17% (or 30%). The contribution of within (sectoral productivity growth) was particularly strong and accounts for about 70% of the increase in aggregate labour productivity for the region. Figure 2.4 presents the dynamics of the contribution of structural change to aggregate labour productivity growth by decades. The analysis shows a positive contribution of structural change to aggregate labour productivity growth in all decades except for 1990-2000. In particular, the analysis shows that before 1990 and after 2000, structural change, has on average, been growth-enhancing contributing positively to aggregate labour productivity growth. A similar observation for the SSA region after 2000 was documented by McMillan and Rodrik (2011).

Table 2.6 further presents the country-level decomposition results.

The analysis shows that structural change was growth-enhancing in most SSA countries. However, there is no systematic relation between structural change and economic growth. For example, the contribution of structural change to overall productivity growth was significantly higher in Botswana, Ethiopia, Kenya, Malawi, and Senegal. However, for these set of countries, only Botswana experienced rapid structural change. Also, although Mauritius had rapid structural change and high aggregate productivity growth, the contribution of structural change was only 20% compared to about 90% in Malawi and Tanzania. Thus, the evidence in support of a close and positive association between economic growth and labour reallocation is mixed and highly non-linear.

### 2.3.3 Model Calibration

To have a better quantitative assessment of productivity growth, labour reallocation, and economic growth, I calibrate the model to 11 countries in SSA. The calibration strategy involves selecting parameter values for the model to match the salient features of the data. There are six parameters of the model to assign values: $\gamma_a$, $\gamma_m$, $\gamma_s$, $\varepsilon$, $\bar{c}_a$, and productivity $A_{it}$ $i \in \{a, m, s\}$ from 1970 to 2010. The study uses country-specific actual expenditure shares from National Accounts to calibrate the parameters $\gamma_a$, $\gamma_m$, and $\gamma_s$. I also calibrates $\varepsilon = 0.5$. This parameter value is taken directly from the literature. The literature estimates $\varepsilon$ to be in the range of 0.10 to 0.90 (see for example Buera and Kaboski, 2009; Dennis and İşcan, 2009). To calibrate $\bar{c}_a$, the study follows the strategy of Duarte and Restuccia (2007, 2010) and Üngör (2013, 2017) and parameterizes the baseline model to a benchmark country. South Korea is selected as the benchmark. To implement this strategy, I set $A_{a,0} = A_{m,0} = 1$ in South Korea in 1970 and calibrates $\varepsilon = 0.5$. The study calibrates $\gamma_a$, $\gamma_m$, $\gamma_s$ to match the actual expenditure shares in total consumption expenditures obtained from National Accounts in South Korea. Using equations (2.9) and (2.10), I calibrate $\bar{c}_a$ and $A_{s,0}$ to match the shares of employment in agriculture $L_{a,0}$, manufacturing $L_{m,0}$, and services $L_{s,0}$ in 1970. The model calibrates $\bar{c}_a = 0.4172$ which is 80% of the total agricultural output $Y_a$ or total food consumption $c_a$ in South Korea in 1970.[10] Next, the study calibrates $\bar{c}_a$ in all countries using South Korea's estimate and set $A_{m,0} = 1$ in each country. Using equations (2.9) and (2.10), $L_{a,0}$, $L_{m,0}$, and $L_{s,0}$ in each country are matched by the implied level of productivity $A_{i,0}$ in 1970. The implied productivity level $A_{i,0}$ together with the growth rates of labour productivity in each sector determine the time path of $A_{it}$ in each country.

The study defines two alternative classifications of industry and services. The narrow definition of industry comprises manufacturing while its broad classification includes manufacturing, mining, construction, and utilities (electricity, gas, and water). The broad classification of services comprises trade, restaurants and hotels, transport, storage and communication, finance, insurance, real estate and business services as well as government, community, social and personal services. Its narrow

[10]This is similar to the estimates by Dennis and İşcan (2009) for the United States in the early 20th century.

Table 2.7: Country-specific actual expenditure shares $\gamma_i,\ \ i \in \{a, m, s\}$

| Country | Agriculture ($\gamma_a$) | Industry ($\gamma_m$) | Services ($\gamma_s$) |
|---|---|---|---|
| Botswana | 0.36 | 0.40 | 0.24 |
| Ethiopia | 0.45 | 0.30 | 0.25 |
| Ghana | 0.51 | 0.26 | 0.23 |
| Kenya | 0.57 | 0.17 | 0.26 |
| Malawi | 0.50 | 0.30 | 0.20 |
| Nigeria | 0.59 | 0.26 | 0.15 |
| South Africa | 0.26 | 0.27 | 0.47 |
| South Korea | 0.13 | 0.29 | 0.58 |

Note: Expenditure share data are not available for Mauritius, Senegal, Tanzania, Zambia and Taiwan. I used data on Kenya for Senegal and Tanzania; Ghana for Zambia; and South Africa for Mauritius.
Source: Data is from the United Nations Database (UNdata) National Accounts. Accessed Accessed May 26, 2016.

Table 2.8: Calibrated subsistence requirement in agriculture $\bar{c_a}$

| Parameter | Narrow classification | Broad classification |
|---|---|---|
| Calibrated Subsistence Requirement ($\bar{c}_a$) | 0.4172 | 0.3702 |

Note: Subsistence requirement is calibrated to match initial labour shares in South Korea in 1970. See text for details.

definition excludes government. The benchmark strategy calibrates the model for narrow sectoral classification and conducts additional robustness analysis using the broad sectoral classifications. Tables 2.7 through to 2.10 present the summary of the model's calibrated parameters.

## 2.4 Quantitative Implications of the Model

To assess the empirical performance of the model, I present two statistics: (i) the root mean square error (RMSE) of the model sectoral employment prediction and (ii) the model's explanatory power (percentage change explained by model). The RMSE is calculated as the

Table 2.9: Implied sectoral productivity in 1970 and ratio of $\bar{c}_a/c_{a,1970}$ for narrow and broad sectoral classifications

| | Narrow classification | | Broad classification | | Narrow classification | Broad classification |
|---|---|---|---|---|---|---|
| Country | $A_{a,1970}$ | $A_{s,1970}$ | $A_{a,1970}$ | $A_{s,1970}$ | $\bar{c}_a/c_{a,1970}$ | $\bar{c}_a/c_{a,1970}$ |
| Botswana | 0.48 | 0.02 | 0.48 | 0.07 | 0.98 | 0.94 |
| Ethiopia | 0.46 | 0.17 | 0.42 | 0.15 | 0.96 | 0.87 |
| Ghana | 0.94 | 0.32 | 1.05 | 0.30 | 0.69 | 0.69 |
| Kenya | 0.56 | 0.19 | 0.54 | 0.18 | 0.89 | 0.82 |
| Malawi | 0.49 | 0.26 | 0.48 | 0.34 | 0.93 | 0.88 |
| Mauritius | 1.17 | 0.20 | 1.66 | 0.37 | 0.75 | 0.85 |
| Nigeria | 0.89 | 0.29 | 0.86 | 0.27 | 0.69 | 0.63 |
| Senegal | 0.64 | 0.24 | 0.66 | 0.23 | 0.82 | 0.79 |
| South Africa | 1.38 | 0.31 | 2.26 | 1.00 | 0.69 | 0.77 |
| Tanzania | 0.47 | 0.26 | 0.44 | 0.27 | 0.95 | 0.87 |
| Zambia | 0.66 | 0.01 | 0.82 | 0.18 | 0.92 | 0.89 |
| South Korea | 1.00 | 0.34 | 1.00 | 0.59 | 0.81 | 0.75 |

Note: $L_{a,0}$, $L_{m,0}$, and $L_{s,0}$ in each country are matched by the implied level of productivity $A_{i,0}$ in each country in 1970

Table 2.10: Annualized labour productivity growth from 1970-2010

| | Narrow classification) | | | Broad classification | | |
|---|---|---|---|---|---|---|
| Country | Agriculture ($A_a$) | Industry ($A_m$) | Services ($A_s$) | Agriculture ($A_a$) | Industry ($A_m$) | Services ($A_s$) |
| Botswana | 1.76 | 2.14 | 2.64 | 1.76 | 2.40 | 2.71 |
| Ethiopia | -0.28 | -1.83 | 0.15 | -0.28 | -1.25 | -0.40 |
| Ghana | 0.67 | -0.56 | 0.47 | 0.67 | -1.15 | 0.06 |
| Kenya | 0.06 | -2.72 | -1.84 | 0.06 | -1.74 | -2.03 |
| Malawi | 1.50 | -0.06 | -1.80 | 1.50 | 0.01 | -1.71 |
| Mauritius | 5.41 | 2.42 | 2.50 | 5.41 | 2.31 | 2.47 |
| Nigeria | 0.93 | 2.69 | 2.35 | 0.93 | 6.27 | 2.40 |
| Senegal | -1.15 | -1.89 | -2.07 | -1.15 | -2.21 | -2.18 |
| South Africa | 2.58 | 0.59 | 0.31 | 2.58 | 1.17 | 0.85 |
| Tanzania | 1.20 | -0.79 | -1.63 | 1.20 | -0.28 | -1.91 |
| Zambia | 0.45 | -0.03 | 2.45 | 0.45 | -0.40 | 2.53 |
| South Korea | 4.54 | 5.06 | 1.06 | 4.54 | 6.56 | 1.06 |

Source: Author's calculation based on the 10-Sector database published by GGDC for the period 1970-2010.

root of the mean square deviation of the model calibrated share of employment from the actual (data) employment share. Thus, $RMSE = \sqrt{\sum \left(L_{it} - \hat{L}_{it}\right)^2}$, where $L_{it}$ is the actual share of employment in sector $i$ at time $t$ and $\hat{L}_{it}$ is the model employment share in sector $i$ at time $t$. This measure takes into account the short-run dynamics and determines

Table 2.11: Quantitative assessment of baseline model for narrow sectoral definitions

| | Agriculture | | | | Industry | | | | Services | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Country | Data | Model | % Explained | RMSE (%) | Data | Model | % Explained | RMSE (%) | Data | Model | % Explained | RMSE (%) |
| Botswana | -40.0 | -22.7 | 56.6 | 19.5 | 6.9 | 3.3 | 48.3 | 4.0 | 33.1 | 19.3 | 58.3 | 15.9 |
| Ethiopia | -14.6 | 14.5 | -99.5 | 36.7 | 4.7 | -4.8 | -102.8 | 10.4 | 9.9 | -9.7 | -98.0 | 26.4 |
| Ghana | -17.2 | -6.9 | 40.3 | 16.2 | -1.4 | 5.3 | -382.3 | 5.1 | 18.6 | 1.6 | 8.7 | 13.3 |
| Kenya | -31.4 | -2.2 | 7.0 | 17.7 | 10.2 | 0.5 | 4.6 | 5.8 | 21.2 | 1.7 | 8.2 | 12.0 |
| Malawi | -17.3 | -14.3 | 82.7 | 11.7 | 1.8 | 3.9 | 214.0 | 4.2 | 15.5 | 10.5 | 67.4 | 7.8 |
| Mauritius | -37.7 | -27.8 | 73.7 | 7.8 | 12.9 | 8.0 | 62.2 | 11.6 | 24.8 | 19.8 | 79.7 | 11.2 |
| Nigeria | -5.0 | 2.3 | -45.1 | 12.3 | -9.0 | -5.8 | 64.7 | 7.1 | 14.0 | 3.6 | 25.5 | 6.2 |
| Senegal | -22.0 | 56.1 | -255.3 | 65.2 | 4.8 | -15.9 | -328.1 | 16.2 | 17.1 | -40.2 | -234.6 | 49.0 |
| South Africa | -23.8 | -13.3 | 55.8 | 7.2 | -0.9 | 3.1 | -335.2 | 1.7 | 24.8 | 10.2 | 41.1 | 8.2 |
| Tanzania | -12.9 | -24.0 | 187.0 | 6.2 | 1.2 | 5.1 | 436.7 | 1.9 | 11.7 | 18.9 | 161.9 | 4.4 |
| Zambia | 7.5 | 5.7 | 76.0 | 15.7 | 0.1 | 1.1 | 1,075.6 | 2.6 | -7.6 | -6.8 | 89.5 | 13.1 |
| South Korea | -43.7 | -33.0 | 75.6 | 9.1 | 5.6 | -3.9 | -70.2 | 10.6 | 38.1 | 37.0 | 97.0 | 3.6 |

Note: Highlighted entries denote 50% or more percentage explained
Source: Author's calculation based on the 10-Sector database published by GGDC for the period 1970-2010.

the fitness of the model in each sector. The analysis sums together the RMSE in all sectors in order to determine the overall model fitness. This approach is standard in the literature.[11] The model's explanatory power, on the other hand, is computed as follows. First, the study determines the model-based change in the share of employment in sector $i$ from 1970 to 2010, $\Delta\hat{L}_{it}$. The model-based change is then compared to the change indicated by data $\Delta L_{it}$ and reported as the proportion (%) explained by model,

$$\text{Percentage Expalained} \quad (\%) = \frac{\Delta\hat{L}_{it}}{\Delta L_{it}} \times 100.$$

### 2.4.1 Baseline Calibration Strategy

Table 2.11 presents the quantitative assessment of the model for the baseline strategy which calibrates the model for common $\bar{c}_a$, $\varepsilon$, country-specific $\gamma_i$, and narrow sectoral classification of industry and services.

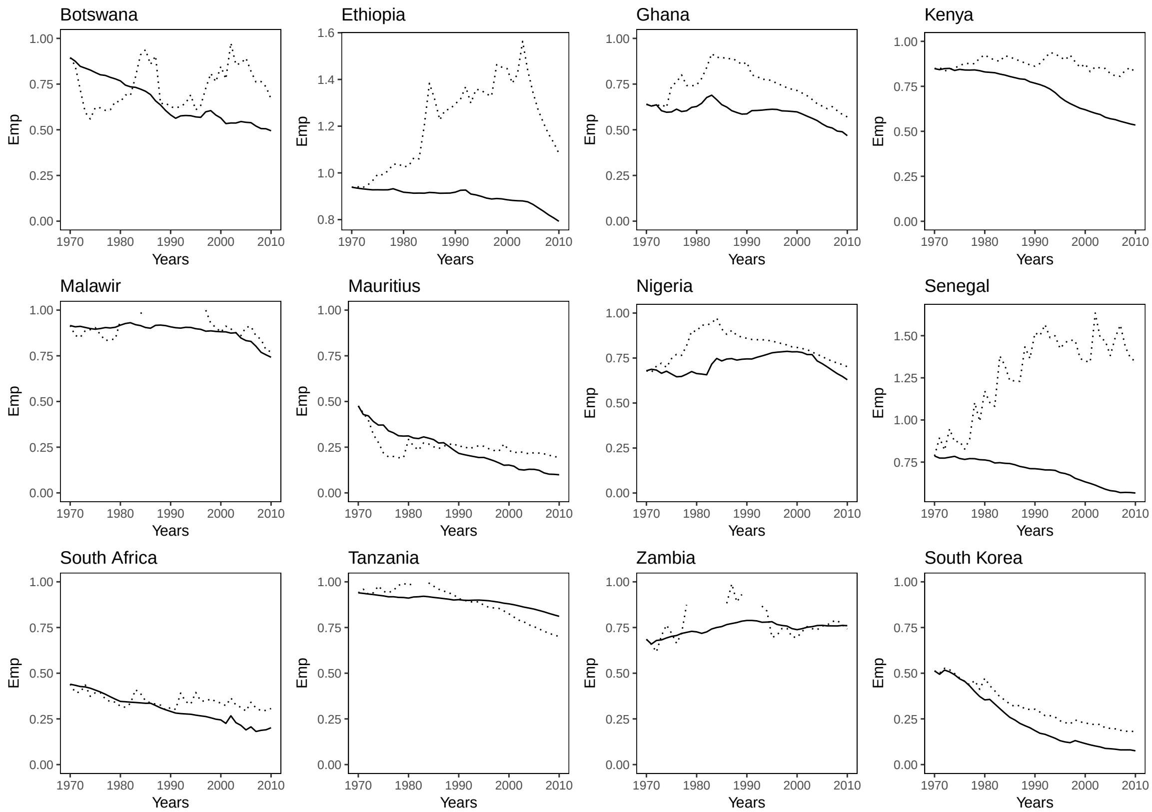
[11] See for example Üngör (2017).

Overall, the explanatory power of the model in accounting for the long-run trend in sectoral labour reallocation in SSA is mixed. On the one hand, the model can account for about 50% of the labour reallocation in agriculture and services in Botswana, Malawi, Mauritius, South Africa, and Zambia. In industry (manufacturing), the model does reasonably well in Botswana, Mauritius, and Nigeria. In Botswana, the model predicts about 23 percentage points decline in the share of employment in agriculture, three percentage points rise for manufacturing, and 19 percentage points rise for services. These compare to an actual decline of 40 percentage points for agriculture, seven percentage rise for manufacturing and 33 percentage points rise for services. Thus, in Botswana, the model accounts for about 60% of the long-term trend in employment shares in agriculture and services, and in manufacturing, about 50%.

Similarly, in Mauritius, the model predicts 27 percentage points decline in the share of employment for agriculture, 8 percentage points rise for manufacturing and 20 percentage points rise for services. These estimates compare to an actual decline of 38 percentage points for agriculture, 13 percentage points rise for manufacturing, and 25 percentage points rise for services. Thus, in Mauritius, the model can account for about 60% of the sectoral labour reallocation. In Malawi, the model explains about 80% of the decline in agricultural employment share and 70% of the rise in services. It, however, does poorly in manufacturing, over-predicting the share of employment in manufacturing by over 100%. In South Africa, it accounts for about 50% of the decline in the share of employment in agriculture and 40% of the rise for services. In manufacturing, the model performs poorly and predicts a rise in employment share rather than a decline as indicated by data. In Zambia, it accounts for 80% of the rise in agricultural employment share, 90% of the decline in services, and fails to account for labour reallocation in manufacturing.

The explanatory power of the model for the rest of the countries is weak. In Ethiopia and Senegal, the model fails to match the long-run trend in sectoral employment shares. The model predicts a rise in the share of employment for agriculture and a decline for manufacturing and services whereas the actual employment shares indicate a decline for agriculture and a rise for manufacturing and services. In Kenya, the data indicates about 30% decline in the share of employment in agriculture, 10% rise for manufacturing and 20% for services compared to the model prediction of 2% decline for agriculture, 0.5% rise for manufacturing, and 1.7% rise for services. In Ghana, the model could account for 40% of the decline in the share of employment in agriculture. However, in services and industry, the model performs poorly. Also, in Nigeria, while the model could account for about 60% of the rise in the share of employment in manufacturing, it performs poorly in agriculture and services. In Tanzania, on the other hand, the model consistently over-predicts the change in sectoral employment shares.

Figure 2.5: Data-based series and calibrated share of employment in agriculture




Note: Solid (—) denotes data and dotted (...) denotes model=based series.
Source: Data is from the 10-Sector Database published by GGDC for the period 1970-2010.

Figure 2.5 plots the actual (data) and model-predicted shares of employment for agriculture. Similar plots for manufacturing and services are presented in the appendix. Its worth noting that in both Ethiopia and Senegal, the model consistently predicts an employment share for agriculture more than one. This is an indication that measured agricultural productivity in both countries has been so abysmal that according to the model allocating all available workers to agriculture would not be enough to meet the subsistence consumption requirement. The evidence also shows that over this period, both Ethiopia and Senegal received substantial food aid support from various humanitarian agencies.

Also, evident from Figure 2.5 is the model's inability to account for the short-run dynamics in sectoral employment shares despite doing reasonably well in matching the long-run sectoral employment shares in many countries. Except in Mauritius, South Africa, and Zambia, the reported RMSEs of the model's prediction for agriculture is more than 10%. In Ethiopia, Mauritius, and Senegal, the RMSE for manufacturing is greater than 10%, and in services, larger than 10% in all countries. The only exceptions are Malawi, Nigeria, South Africa, and Tanzania. Also, except for South Africa and Tanzania, the total RMSE is greater than 20% in all countries and is unusually high for Ethiopia and Senegal.

In sum, the model does reasonably well in accounting for about 50% of the labour reallocation in the long-run in 40% of the sample. It is, however, only able to explain the short-run dynamics in sectoral employment shares in less than 20% of the sample.

### 2.4.2 Robustness Analysis

#### Alternative Calibration Strategies

To determine the robustness of the overall findings of the study, I explore three alternative calibration strategies. In particular, while the baseline strategy calibrates the model for common $\bar{c_a}$, $\varepsilon = 0.5$, and

Table 2.12: Quantitative assessment for alternative calibration strategies in agriculture

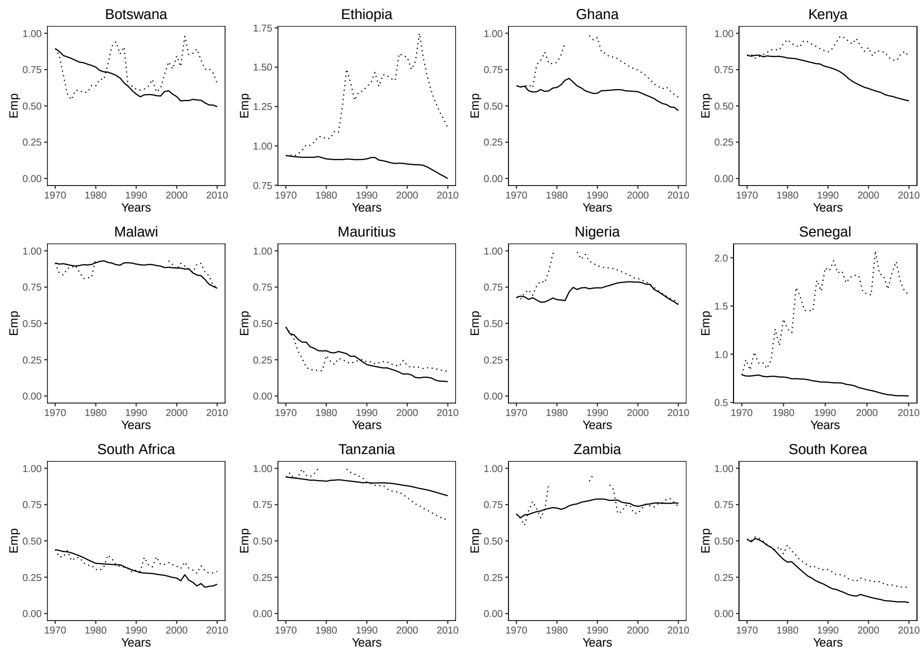
| | | $\varepsilon = 0.1$ | | | Common $\gamma_i$ for all Countries | | | $\bar{c}_a/Y_a = 90\%$ | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Country<br>Country | Data | Model | % Explained | RMSE Relative to Baseline | Model | % Explained | RMSE Relative to Baseline | Model | % Explained | RMSE Relative to Baseline |
| Botswana | -40.0 | -21.4 | 53.4 | 1.0 | -23.9 | 59.8 | 1.0 | -14.0 | 34.9 | 1.0 |
| Ethiopia | -14.6 | 13.8 | -94.4 | 0.6 | 17.6 | -120.4 | 1.2 | 8.3 | -57.2 | 0.9 |
| Ghana | -17.2 | -9.1 | 52.8 | 1.6 | -8.0 | 46.5 | 1.4 | -8.6 | 49.9 | 1.1 |
| Kenya | -31.4 | -3.2 | 10.1 | 1.0 | -0.9 | 2.9 | 1.1 | -2.0 | 6.3 | 1.0 |
| Malawi | -17.3 | -16.4 | 94.5 | 0.8 | -16.7 | 96.4 | 1.3 | -12.4 | 71.6 | 0.9 |
| Mauritius | -37.7 | -30.9 | 81.9 | 1.0 | -30.3 | 80.5 | 1.0 | -33.7 | 89.3 | 1.0 |
| Nigeria | -5.0 | 6.2 | -125.0 | 1.6 | -3.8 | 76.6 | 1.4 | -7.1 | 141.6 | 1.3 |
| Senegal | -22.0 | 64.8 | -294.9 | 1.3 | 83.4 | -379.5 | 1.4 | 73.7 | -335.3 | 1.1 |
| South Africa | -23.8 | -15.0 | 63.1 | 0.8 | -15.0 | 63.0 | 0.9 | -18.1 | 75.8 | 0.9 |
| Tanzania | -12.9 | -28.8 | 223.7 | 0.6 | -29.8 | 232.1 | 1.4 | -18.5 | 143.6 | 1.3 |
| Zambia | 7.5 | 7.4 | 99.1 | 0.9 | 5.2 | 69.2 | 1.2 | 5.8 | 78.2 | 1.0 |
| South Korea | -43.7 | -35.0 | 80.1 | 0.7 | -33.0 | 75.6 | 1.0 | -36.8 | 84.2 | 0.9 |

Note: Assessment of the empirical model for agricultural employment share $L_{it}$ Source: Author's calculation based on the 10-Sector database published by GGDC for the period 1970-2010.

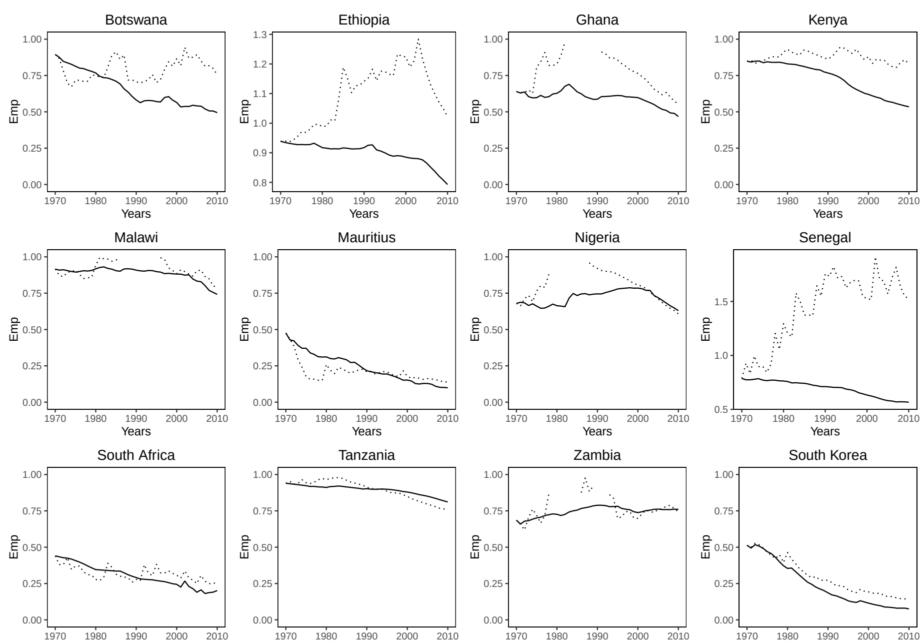
country-specific expenditure shares, the first alternative strategy calibrates the model for common $\bar{c}_a$, country-specific $\gamma_i$, $i \in \{a, m, s\}$, and $\varepsilon = 0.1$. The second strategy disciplines the preference parameters and calibrates the model for common $\bar{c}_a$, $\varepsilon = 0.5$, and common expenditure shares $\gamma_i$ $i \in \{a, m, s\}$ for all countries using the benchmark (South Korea) estimates. The third strategy explores variations in $\bar{c_a}$ across countries and calibrates $\bar{c}_a$ in each country to match $\bar{c}_a/c_a = 90\%$. In the sample, Ethiopia is the poorest and 90% of farms produce primarily for subsistence consideration (see chapter 3). Elasticity of substitution $\varepsilon$ is calibrated to be 0.5 and the consumption share parameters $\gamma_a$, $\gamma_m$, $\gamma_s$ calibrated to match the country-specific actual expenditure shares from National Accounts.

Table 2.12 presents the results of the analyses for the agricultural sector. Relative to the baseline, the analysis shows no significant improvement in overall explanatory power / fitness of the model except

Figure 2.6: The share of employment in agriculture: alternative calibration strategies




(a) Model calibrated for common $\gamma_i$ for all countries




(b) Model calibrated for $\bar{c_a}/Y_a = 90\%$

Note: Solid (—) denotes data and dotted (...) denotes model.
Source: Data is from the 10-Sector database published by GGDC for the period 1970-2010.

in a few cases. In Ghana, Mauritius, and South Africa, all three alternative strategies slightly improve the model's explanatory power for agriculture. In Malawi, the explanatory power only improves for the second strategy that calibrates the model for $\varepsilon = 0.1$ and common consumption/expenditure shares $\gamma_i$. In Zambia, it improves slightly for the strategy calibrating the model for $\varepsilon = 0.1$ and in Botswana and Nigeria, only for the strategy with common consumption shares $\gamma_i$ for all countries. Also, except in Ethiopia, Malawi, South Africa, Tanzania, and Zambia, the fit of the model for agriculture and overall fit (based on the total RMSE) shows no significant improvement and even worsen for Ghana, Nigeria, Senegal, and Tanzania. Figure 2.6 further plots the data-based and model-based series for agriculture; the results are qualitatively similar to the baseline strategy. The model still fails to match the long-run trend in sectoral employment shares in Ethiopia, Kenya, and Senegal, and in Tanzania, consistently predicts a lower share of employment in agriculture than observed in data and over-predicts for industry (manufacturing) and services.

### Alternative Sectoral Classifications

Table 2.13 presents additional evidence on the robustness of the results. In particular, the analysis calibrates the model for broad sectoral classification of industry and services. I present the result of the analysis for agriculture. Similar results for industry and services are presented in appendix A. In Malawi, Mauritius, South Africa, and Zambia, the

Table 2.13: Quantitative assessment of model for broad classification of industry and services

| Country | | $\varepsilon = 0.5$ | | | Common $\gamma_i$ for all Countries | | | $\bar{c}_a/Y_a = 90\%$ | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Country | Data | Model | % Explained | RMSE relative to baseline | Model | % Explained | RMSE relative to baseline | Model | % Explained | RMSE relative to baseline |
| Botswana | -43.9 | -16.2 | 36.9 | 1.4 | -18.3 | 41.7 | 1.4 | -14.0 | 31.9 | 1.4 |
| Ethiopia | -17.2 | 14.1 | -81.6 | 1.0 | 17.1 | -99.3 | 1.2 | 9.3 | -53.8 | 0.7 |
| Ghana | -15.5 | -4.9 | 31.4 | 0.8 | -6.3 | 40.4 | 1.1 | -7.4 | 47.6 | 1.4 |
| Kenya | -32.7 | -3.0 | 9.0 | 1.0 | -1.3 | 3.9 | 1.2 | -2.1 | 6.5 | 1.1 |
| Malawi | -21.5 | -13.4 | 62.4 | 0.9 | -15.6 | 72.7 | 1.2 | -14.1 | 65.4 | 1.0 |
| Mauritius | -30.1 | -19.1 | 63.4 | 0.9 | -21.5 | 71.3 | 0.8 | -26.9 | 89.2 | 0.8 |
| Nigeria | -6.7 | -2.2 | 32.3 | 0.9 | -7.1 | 104.6 | 1.3 | -10.1 | 149.5 | 1.6 |
| Senegal | -21.8 | 49.0 | -224.5 | 0.9 | 75.5 | -345.8 | 1.3 | 73.4 | -336.0 | 1.3 |
| South Africa | -19.7 | -9.6 | 48.7 | 0.9 | -10.9 | 55.3 | 0.8 | -14.9 | 75.7 | 0.6 |
| Tanzania | -18.0 | -23.0 | 128.0 | 0.8 | -28.7 | 160.1 | 1.2 | -21.0 | 116.7 | 0.7 |
| Zambia | 10.1 | 5.9 | 59.0 | 0.6 | 5.3 | 52.7 | 0.8 | 5.0 | 49.7 | 0.9 |
| South Korea | -42.1 | -29.7 | 70.6 | 1.2 | -29.7 | 70.6 | 1.2 | -35.4 | 84.0 | 0.7 |

Source: Data is from the 10-Sector Database published by GGDC for the period 1970-2010

model could account for about 50% of the change in the sector's employment share over the sample period. The explanatory power is weak for the rest of the countries, and in Ethiopia, Kenya, and Senegal for example, the model fails to reasonably account for labour reallocation. In industry, the model performs best for Botswana, Malawi, and Mauritius, and for service,s performs better only in Malawi and Mauritius.

However, a comparison of these results to the baseline shows no significant improvement in the fitness of model or its explanatory power for most of the countries. The RMSE of the model's prediction for sectoral employment shares relative to the baseline only improves marginally for Mauritius and Zambia. In Botswana, Nigeria, and Senegal, the relative RMSE increases.

### 2.4.3 A Counter-factual Analysis

The preceding analyses show that the explanatory power of the model is weak for most countries and this section further investigates the sources of the model's failure. In particular, I ask the question: is the failure of the model an artifact of the data (i.e. data-driven) or given an appropriate data source, we can trust the model to deliver insights into the structural transformation in SSA? To answer this question and have a further quantitative assessment of sectoral productivity growth and labour reallocation, the study conducts a counter-factual analysis based South Korea's productivity growth rates. In particular, the study computes the counter-factual by replacing productivity growth rates in each sector in SSA with the corresponding growth rates of South Korea. Three counter-factual analyses are performed in order to separately evaluate the role of agricultural productivity growth (agricultural-led) and manufacturing productivity growth (industrialization-led) for structural transformation in SSA. The first exercise simulates the model replacing only productivity growth in agriculture in SSA with the corresponding growth rate of South Korea; $A_m$ and $A_s$ are determined by the actual productivity growth rates in each country. The second exercise, on the other hand, replaces only manufacturing productivity growth rates in SSA with the corresponding growth rates of South Korea; $A_a$ and $A_s$ are given by the data in each country. The third exercise replaces productivity growth rates in all sectors in

Table 2.14: Counter-factual analyses using South Korea's sectoral productivity growth rates

| | | Benchmark | Productivity growth rates | | Productivity growth rates (All sectors) | | |
|---|---|---|---|---|---|---|---|
| Country | Data | Model-Based[1] | Agriculture only | Manufacturing only | Country-specific $\gamma_i$ | Common $\gamma_i$ | $\bar{c}_a/y_a = 90\%$ |
| Botswana | -40.0 | -22.7 | -65.5 | -22.1 | -64.2 | -46.2 | -66.5 |
| Ethiopia | -14.6 | 14.5 | -62.7 | 13.5 | -54.6 | -35.7 | -62.7 |
| Ghana | -17.2 | -6.9 | -39.7 | -0.9 | -30.4 | -43.4 | -39.0 |
| Kenya | -31.4 | -2.2 | -57.6 | -1.0 | -45.9 | -48.1 | -58.3 |
| Malawi | -17.3 | -14.3 | -59.7 | -12.3 | -47.6 | -39.5 | -57.7 |
| Mauritius | -37.7 | -27.8 | -28.5 | -25.8 | -29.1 | -34.6 | -31.5 |
| Nigeria | -5.0 | 2.3 | -25.7 | 2.4 | -29.7 | -44.8 | -40.2 |
| Senegal | -22.0 | 56.1 | -36.5 | 52.4 | -40.6 | -48.7 | -52.9 |
| South Africa | -23.8 | -13.3 | -27.8 | -10.6 | -25.2 | -32.0 | -27.7 |
| Tanzania | -12.9 | -24.0 | -60.8 | -22.2 | -49.1 | -35.7 | -63.5 |
| Zambia | 7.5 | 5.7 | -47.6 | 6.5 | -48.6 | -47.3 | -52.1 |
| South Korea | -43.7 | -33.0 | -33.0 | -33.0 | -33.0 | -36.8 | -33.0 |

Note:
1 Denotes the model predicted $\Delta L_a$ based on the benchmark model calibrated using country-specific (actual) productivity growth rates.
Source: Data is from the 10-Sector Database published by GGDC for the period 1970-2010.

SSA with the corresponding sector-productivity growth rates in South Korea. In all the counter-factual analyses, $A_{i,1970}$ $i \in \{a, m, s\}$ are determined by the implied country-specific productivity levels in 1970. However, the time path for each sector's productivity for $t > 1970$ is determined by the corresponding growth rates in South Korea.

Table 2.14 presents the results of the analyses for the agricultural sector. I report the $\Delta L_a$ implied by the data and model-based series. Overall, the analysis shows that given an appropriate data source, the model can deliver a good insight into structural transformation in SSA. The analysis is indicative that raising sectoral productivity growth rates is essential for labour reallocation in SSA. This would have led to a faster labour reallocation away from agriculture to non-agriculture in most SSA countries. The only exception is Mauritius.[12]

[12] Productivity growth rates in Mauritius, particularly, in agriculture and services were stronger than those of South Korea.

In Ethiopia, for example, while the benchmark model-based series indicates a 15 percentage points rise in $L_a$, the counter-factual analysis replacing productivity growth in all sectors and calibrated for country-specific $\gamma_i$ shows that $L_a$ could have declined by over 50 percentage points. This change compares to an actual (data) decline of about 15 percentage points. In Malawi, the analysis shows that $L_a$ could have declined by almost 50 percentage points. This change compares to an actual decline of 17 percentage points and 14 percentage points as implied by the baseline model-based series. In Tanzania, $L_a$ could have declined by approximately 50 percentage points, compares to the decline of 24 percentage points as implied by the benchmark model-based series, and in Nigeria, it could have declined by almost 30 percentage points. In Zambia, on the other hand, while the data and benchmark model-based series indicate a about ten percentage points rise in $L_a$, the counter-factual analysis indicates a decline of almost 50 percentage points.

A further quantitative assessment shows a relatively stronger contribution of agricultural-led productivity growth to labour reallocation than industrialization. Almost, all the gains in labour reallocation could be explained by the strong productivity growth in agriculture, with manufacturing productivity growth playing a minimal role. In Ethiopia, Nigeria, Senegal, and Zambia, the counter-factual replacing only agricultural productivity growth in SSA leads to a significant decline in $L_a$, and the correlation coefficient between the predicted change in $L_a$ given by model and the data-based series for the sample is about 0.90. By contrast, a similar exercise replacing only manufacturing productivity growth in SSA with that of South Korea instead predicts a rise in $L_a$ for these countries. For the rest of the sample, the agricultural-led structural change is stronger than industrialization-led suggesting an essential role for the agricultural sector in the structural transformation of SSA.

## 2.5 Conclusion

In SSA, agriculture is dominant and accounts for about 50% of total employment in Ethiopia, Malawi, Nigeria, Senegal, Tanzania, and Zambia. Yet, agriculture continues to have low value-added per worker and mainly for subsistence. This chapter thus examines the economic determinants of labour reallocation in 11 countries in SSA using a three-sector general equilibrium model that integrates the demand and supply drivers of structural change. The demand channel arises from productivity growth in agriculture combined with a low income elasticity of demand for agricultural goods. The supply channel, on the other hand, arises from differences in sectoral productivity growth combined with complementarities between agriculture and non-agricultural goods. Overall, the demand and supply drivers combine to explain about 50% of the change in the share of employment in agriculture in 40% of the sampled countries, namely Botswana, Malawi, Mauritius, and South Africa. In the rest of the sample, the explanatory power is weak and in particular, fails to reasonably account for labour reallocation in Ethiopia, Kenya, Nigeria, Senegal, and Tanzania. A counter-factual analysis replacing productivity growth rates in each sector in SSA with the corresponding sectoral productivity growth rates in South Korea also suggests that raising productivity in SSA is essential for structural transformation in SSA. However, the contribution of an agricultural-led productivity growth to labour reallocation is much stronger than an industrialization-led productivity growth.

The failure of the model in accounting for labour reallocation in several SSA countries is an indication of the necessity of further theoretical and empirical work on this topic. Traditional models incorporating one or both channels (i.e. demand and supply drivers) of structural change are simplified descriptions of the actual transformations and do not incorporate important factors such as institutions and cultural factors, demographic transition, factor market imperfections/distortions, quality of labour (human capital), home production, and government policies that are potentially relevant for structural transformation in SSA. The model, for example, assumes that labour reallocation is a response to changes in productivity. However, the rise in urbanization and urban slums in recent years in many developing countries (see for example Marx, Stoker, and Suri (2013)) point to a new trend where labour migrates from rural areas which are predominantly agricultural to the urban centers in search for better living conditions. In many instances, this transition has happened despite the absence of productivity improvement in agriculture or faster productivity growth in non-agriculture. Fulginiti, Perrin, and Yu (2004) emphasize the importance of institutional factors such as political rights and civil liberties in driving agricultural productivity growth, economic growth, and thus structural transformation in SSA. Carraro and Karfakis (2018) further highlight the importance of institutional qualities and economic freedom in driving labour reallocation in SSA. Other authors such as Block (2010), Dennis and İşcan (2011), and O'Gorman (2015) emphasize the role of government policies in the structural transformation process while Buera and Kaboski (2009) argue for a model that incorporates home production, sector-specific factor distortions, and differences in human capital accumulation across sectors. Incorporating these factors and alternative mechanisms could thus amend standard models, but are beyond the scope of this dissertation.

# Chapter 3

## Commercialization and Productivity in Agriculture: Micro-level Evidence from Sub-Saharan Africa

### 3.1 Introduction

Agriculture is central to understanding economic development, aggregate labour productivity (gross output per worker), and income disparities between sectors and across countries.[1] Also, labour released by agriculture is critical to structural transformation. In Sub-Saharan Africa (SSA), agriculture remains the backbone of many economies. The sector accounts for significant share of employment in total employment; over 50% in Ethiopia, Malawi, and Tanzania. Yet, productivity in agriculture is low by international standards. In SSA, there is low adoption of high yield varieties, low fertilizer use and low agricultural mechanization (Diao, Hazell, and Thurlow, 2010; O'Gorman, 2015). Also, agricultural production units tend to be predominantly small and subsistence-based, with farmers producing using rudimentary techniques, with little or no use of modern agricultural inputs. The ultimate cause of low adoption of modern agricultural inputs and slow productivity growth have been variedly stated as low government and private investment in agriculture (O'Gorman, 2015), insecure property

[1] See Hayami and Ruttan (1970); Restuccia et al. (2008); Gollin et al. (2002);Gollin, Lagakos, and Waugh (2014a); Gollin, Lagakos, and Waugh (2014b); Block (2010); McMillan and Rodrik (2011); Lagakos and Waugh (2013).

rights, and a lack of land markets (Restuccia and Santaeulalia-Llopis, 2017), discriminatory policies against agriculture (Dennis and İşcan, 2011), selection bias in agriculture (Lagakos and Waugh, 2013), and imperfect financial markets (Carter, 1988; Carter and Wiebe, 1990; Feder, Lau, Lin, and Luo, 1990).

While increasing agricultural productivity is key to accelerating structural transformation in SSA, commercialization of agriculture, defined as a transition from subsistence-based to market-based farming, has been made a policy priority. For example, the official agricultural policy in Ethiopia emphasizes the acceleration of agricultural commercialization and increasing the proportion of marketed agricultural output. In Ghana and Nigeria, the policy is aimed at increasing the sector's competitiveness and market integration, and in Tanzania, the policy emphasizes the transformation of agriculture from subsistence to commercial and to a modernized sector. However, there is no systematic evidence on the merits of commercialization in raising productivity.

This chapter uses a standardized survey data from the Living Standard Measurement Survey (LSMS) - Integrated Surveys on Agriculture to study farm-level productivity in five countries (Ethiopia, Ghana, Malawi, Nigeria, and Tanzania) in SSA and distinguishes between two farm types: subsistence and commercial farms. A commercial farm is defined as any farm producing primarily for market purposes. The chapter tests if there are productivity differences across farm types and study the implications of farm commercialization for labour reallocation in SSA. To make inferences about production efficiency across farms, this chapter employs econometric techniques to characterize the production technology of farm types, estimates total factor productivity (TFP) and technical efficiency across subsistence and commercial farms, and quantitatively assesses the impact of commercializing subsistence farms for labour reallocation away from agriculture to non-agriculture.

In all the countries studied, there is significant dispersion in inputs use and land/labour productivity across the two farm types. The study also estimates positive and statistically significant output elasticity of inputs for each farm type. However, the differences in input elasticities across farm types are not statistically significant. The evidence, thus, suggests that farm types are characterized by a common production technology. Additional evidence based on TFP estimates shows no marked differences in TFP across subsistence and commercial farm types in Ethiopia, Malawi, and Nigeria. In Tanzania, TFP is about 10% higher for commercial farms than subsistence farms, and in Ghana about 15% higher for commercial farms than subsistence farms. Nonetheless, both commercial and subsistence farms exhibit substantial technical inefficiencies, and the average farm produces about 50% below the efficiency frontier; i.e., relative to the best practice farms. These findings thus account for the co-existence of subsistence and commercial farms as an equilibrium outcome in SSA. They also provide opportunities for output improvement through production reorganization.

To examine the implications of farm commercialization for labour reallocation, I use a two-sector version of a model developed in chapter 2 of the dissertation. The framework integrates differential demand growth across the sector's output (demand channel) and differential productivity growth across sectors (supply channel). The differential demand growth channel arises from productivity growth in agriculture combined with a low income elasticity of demand for agricultural goods. The differential productivity growth channel, on the other hand, arises from differences in sectoral productivity growth with complementarities between agriculture and non-agricultural goods. Overall, the analysis shows that in the best-case scenario (represented by a 15% rise in agricultural productivity), commercialization of subsistence farms could lead to about ten percentage point reduction in the share of employment in agriculture in Ethiopia, Malawi, and Tanzania.

This chapter with its focus on subsistence-commercial dimension is most relevant for the structural transformation in SSA. Most of the micro studies on farm-level productivity emphasize farm-size heterogeneity and are mostly focused on Asia and Latin America. The macro literature, on the other hand, tends to focus on differences in value-added per worker (labour productivity) across sectors, across countries, and across sector-country pairs, or treat agriculture as a homogenous sector. In reality, agriculture in SSA comprises both "traditional" (subsistence) and "modern" (commercial) establishments, and so far the literature has not paid sufficient attention to this particular duality, and its implications for agricultural outcomes, particularly, for productivity and labour reallocation.[2] Duality could also have implications for labour reallocation both across farm types and beyond agriculture. While the term small and large farms are interchangeably used for subsistence and commercial farms, this chapter makes a distinction between these broad farm categories. A subsistence farm in this context refers to any farm that consumes 100% of its total output (i.e. pure subsistence). In the five countries considered in this study, the subsistence farm constitutes from about 30% of the farms in Ghana to over 90% in Ethiopia. A small farm, on the other hand, is typically defined as a farm of size two hectares or less and ranges from about 80% of all farms in Ghana to almost the entire sample in Ethiopia and Malawi. The subsistence-commercial approach adopted in this study thus overcomes major weaknesses in the small-large dichotomy and the conventional approach of classifying small-holding farms as subsistence. The data shows that not all small-farm holdings are subsistence neither are all large farms commercial. While there are significant overlaps across the different dimensions of farm classifications, labour reallocation may

[2]See for example Hayami and Ruttan (1970); Fulginiti and Perrin (1998) Restuccia et al. (2008); McMillan and Rodrik (2011); Lagakos and Waugh (2013); Adamopoulos and Restuccia (2014); Gollin et al. (2014a); Gollin et al. (2014b).

not necessarily be from small to large farms. When there are substantial differences in labour productivity across farm types, agricultural labour may over time reallocate from the low-productivity subsistence farm to the high-productivity commercial establishment regardless of their plot sizes.

The rest of the chapter is as follows. Section 2 provides the literature review. Section 3 provides a discussion on country-specific policies directed towards the agricultural sector for the countries under consideration. Section 4 presents the methodology, data, and estimation considerations of the production functions. Section 5 presents the results and discussions of the tested hypothesis. Section 6 concludes, and Appendix B presents a detailed discussion of the data sources.

## 3.2 Related Literature

This study broadly relates to studies that emphasize farm heterogeneity and examine the implications of farm heterogeneity for agricultural productivity. However, unlike the large body of literature emphasizing farm-size heterogeneity, and mostly on Asia and Latin America, this chapter studies farm-level productivity in SSA and emphasize farm-type heterogeneity based on the market orientation of farms.[3]

[3]See (e.g Lau and Yotopoulos, 1971; Bardhan, 1973; Bagi, 1981). See also Fan and Chan-Kang (2005) for an extensive review of this literature.

### 3.2.1 Farm-size and Farm Productivity in SSA

The relation between farm size and farm productivity has been a long-standing debate in agricultural economics. While this body of literature has primarily focused on Asia and Latin America, evidence from SSA is minimal. Moreover, the existing studies on SSA have so far produced mixed results. For example, Dorward (1999) uses micro-level data from Malawi to investigate the relationship between farm-size and farm productivity for smallholder farms in Malawi and provide evidence in support of a positive relation between farm-size and farm productivity. The author attributes this positive relation to the failure of land, capital, and output markets thus affecting both the use of capital and labour inputs on smallholder farms in Malawi. Ali and Deininger (2015), on the other hand, use plot-level data from Rwanda and find an inverse relationship between farm size and crop output per hectare (i.e. land productivity). This inverse relation, however, disappears when family labour is valued at market rates. Their findings thus support labour-market imperfections as the critical driver of the inverse farm-size productivity relationship. Akudugu (2016) examines the importance of farm-size and farm credit (from both formal and informal sources) for farm productivity in Ghana. The study finds that access to credit has a positive effect on farm productivity. However, there is no linear statistically significant relationship between farm size and farm productivity. More recently, Desiere and Jolliffe (2018) using plot-level data from Ethiopia show that the inverse relationship between farm size and productivity is an artifact of systematic over-reporting of production by small holding farms, and under-reporting by farmers on large plots. Using an alternative approach based on crop cuts to estimate crops yield, the authors estimate a strong inverse relation for the sample based on self-reported production, a result that disappears for the crop-cut estimates. The present study, nonetheless, differs from these studies with its focus on differences in farm productivity across farm-types rather than farm-sizes.

### 3.2.2 Market (Commercial) and Non-Market (Subsistence Farming) in SSA

The importance of integrating small and subsistence farms into broader development policies has long been recognized. Some authors have examined the conceptual framework for agricultural commercialization in developing countries. These studies emphasize both demand and supply forces and government policies in driving agricultural commercialization. For example, Von Braun (1995) examines the role of agricultural commercialization in development and the role of policies in affecting commercialization outcomes using macroeconomic indicators. The author identifies stable macroeconomic environment, non-distortionary trade policies, infrastructure development, and the legal environment as the driving forces of agricultural commercialization and argues that policies that affect these factors will also affect the nature and speed of the commercialization process. The author also finds that whereas commercialization simultaneously increases labour productivity in agriculture, its effect on employment is ambiguous and largely depends on the choice of crop and technology. Pingali and Rosegrant (1995) provide a systematic review and document that the transition from subsistence-based production to a market economy would involve significant changes in the product mix and input use, mostly driven by market profitability. The authors identified rising opportunity costs of family labour and increasing demand for food as the main determinants of agricultural commercialization. They also emphasize the role of government policies in the areas of rural infrastructure investment, crop improvement research, and the establishment of secure property rights in ensuring a smooth transition to a market-based economy.

Pingali (1997), on the demand side, identifies rapid income growth and diversification in food demand patterns as the key drivers of agricultural commercialization. On the supply side, the author identifies growing factor scarcity such as land and water as the main drivers of commercialization. Pingali (1997), further advocates that in the short-term government policies should be focused on addressing transitional issues (e.g. income inequality) while long-term strategies should be aimed at increasing investment in rural markets, transportation and infrastructure, crop improvement research and management, and establishing secure land and water rights. Nepal and Thapa (2009) also advocate for the strengthening of rural-urban linkage through the development of physical infrastructures such as roads and irrigations, increasing the supply of chemical inputs, and promoting a labour-saving technology adoption.[4]

By contrast, others have attempted to estimate total factor productivity across different farm types. For example, Thirtle, Atkins, Bottomley, Gonese, Govereh, and Khatri (1993b) use macro-level data to construct TFP indices for farms in Zimbabwe and also to estimate the growth in the land, labour, and total factor productivity across communal and commercial farms from 1970 to 1990. Their findings show that while TFP growth has been impressive in all farms, growth has been particularly strong for communal farms than commercial farms. Between 1970 and 1990, land, labour, and TFP grew at an annualized rate of 6.9%, 7.0%, and 4.6% respectively in communal farms. This compares to an annualized growth rate of 5.2% for land, 6.4% for labour, and 3.4% for TFP in commercial farms. The authors cite government policies aimed at improving the performance of agriculture in communal areas as responsible for driving productivity growth in communal farms. In the empirical estimation of the production functions, Thirtle et al. (1993b) identify R & D and extension investments as the critical determinant of TFP growth in commercial farms; the two factors explain about 90% of the variance in TFP. Weather index was found to be the primary driver of TFP changes in communal farms.

[4] See Jaleta, Gebremedhin, and Hoekstra (2009) for a comprehensive review of the conceptual framework and methodological issues for smallholder agricultural commercialization.

Thirtle, Atkins, Bottomley, Gonese, and Govereh (1993a) also construct a TFP index for the commercial agriculture in Zimbabwe using aggregate farm production account data and estimate an average annualized TFP growth of 3% for the commercial sector between 1970-1989. The authors attributed the growth in TFP in commercial farms partly to input intensification. The authors, however, cite government policies that have mostly discriminated against commercial agriculture in Zimbabwe as the main constraint to TFP growth in commercial farms. According to Thirtle et al. (1993a), discrimating policies (such as resettlement schemes) against commercial farms led to lost of farmland for commercial agriculture and also commercial farms shed labour due to minimum wage legislation. Also, the policies resulted in more resources allocated to communal farms at the expense of commercial farms; the share of commercial agriculture in government-controlled research resources declined over this period. Thus, according to Thirtle et al. (1993a), these factors pressured commercial farms to intensify their input use and increase efficiency. For example, the minimum wage legislation led to the substitution of machinery for labour in commercial farms.

Restuccia and Santaeulalia-Llopis (2017), use household micro-level data to measure farm-level TFP across marketed (purchased) and non-marketed (customary) farmlands in Malawi, and find severe inefficiencies across both farm types. The authors estimate that an efficient reallocation of factors, particularly, capital and land could increase agricultural productivity by a factor of 3.6. However, the gains are more significant for non-marketed farmlands than for marketed farmlands. Abate, Bernard, de Brauw, and Minot (2018), using a randomized control trial, examine the impact of the adoption of the Wheat Initiative package of technologies on yields among a promotional group of farmers in Ethiopia. This package includes the adoption of improved techniques, improve inputs, and a guaranteed market for the crop. The authors find that while the Wheat Initiative was successful in making certified seed and fertilizer accessible to farmers and increasing their uptake, the adoption of the complete package increases the average yield of wheat by 14% at harvest. The authors cite incomplete adoption of the recommended practices by the interventionist farmers and adoption of partial practices by the controlled farmers as reasons for the low observed yield difference associated with the Wheat Initiative technology adoption at harvest.

The present study differs from these past studies in focus and scope. Unlike Thirtle et al. (1993a) and Abate et al. (2018), this chapter uses detailed plot-level data and examine farm-level productivity across subsistence and commercial farms. Restuccia and Santaeulalia-Llopis (2017) examine differences in productivity across marketed and non-marketed farmland in Malawi. This chapter tests if there are productivity differences across subsistence and commercial farms in five SSA countries, and uses a nationally representative household-level survey data. The chapter also quantitatively examines the general equilibrium implications of differences in farm productivity for labour reallocation away from agriculture. Moreover, while most past studies tend to focus on limited measures of productivity, this chapter estimates land, labour, TFP, and technical efficiency across farm types. Traditional theories place agriculture at the heart of the structural transformation process and studies labour reallocation across sectors [see e.g. Gollin et al. (2002); Restuccia et al. (2008); Diao et al. (2010); Dennis and İşcan (2011); Üngör (2013); O'Gorman (2015)]. By explicitly accounting for the dispersion of productivity across farm types, this study differs significantly from the existing studies on structural change that largely ignore this margin.

## 3.3 Agriculture in Perspective

This section examines the aggregate data on employment, productivity and input use, and country-specific characteristics and policies geared towards the agricultural sector in SSA.

### 3.3.1 Employment, Productivity and Productivity Gap in Agriculture

Agriculture remains the backbone of many economies in developing countries. In SSA for example, agriculture accounts for a significant share of total employment and gross domestic product (GDP). Table 3.1 shows the share of agriculture in total employment and value-added in 2010 for the five SSA countries used in this study as well as for South

Korea and the United States for comparison.[5] The share of employment in agriculture remains relatively high, especially, in Ethiopia (75%), Tanzania (73%) and Malawi (65%). Also, agriculture accounts for almost 20% of the total value-added in Ethiopia, Nigeria, and Tanzania. Yet, labour productivity (value-added per worker) in agriculture is low, and the productivity gap (measured relative to the United States) is more pronounced in agriculture than in non-agriculture (see Table 3.1).[6] The average labour productivity (value-added per worker) in Ethiopia, Malawi, and Tanzania is less than 2% of the productivity in the United States, and the labour productivity gap (measured relative to the US) is particularly pronounced in agriculture in these countries. In Tanzania, the labour productivity gap is a multiple of 60 in agriculture compared to only 9 in industry. In Malawi, the gap is 66 in agriculture compared to 21 in the industry, and in Ethiopia, it is a multiple of 62 in agriculture compared to 36 in industry.

Table 3.2 presents additional evidence on low agricultural productivity in SSA. The table shows the average yield and growth in cereal yield for the period 1961-2012 for the five SSA countries, South Korea and the United States. Cereal yield is measured in kilograms per hectare of harvested land and comprises wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains. Despite the significant

[5]South Korea is included in the comparison group for the following reasons. In the late 1960s, South Korea's economy was similar to most SSA countries. However, four decades later, the country has been able to transform its economy is one regarded as one of Asian's giants.

[6]The value-added per worker and productivity gap estimates are not adjusted for differences in hours worked or human capital.

Table 3.1: Employment share, value-added and labour productivity gap in agriculture (2010)

| | Share of agriculture | | Value-added per worker | | Labour productivity gap | | GDP per |
|---|---|---|---|---|---|---|---|
| Country | Employment | Value-added | Agriculture | Industry | Agriculture | Industry | capita |
| Ethiopia | 0.75 | 0.17 | 1,110 | 2,956 | 62 | 36 | 935 |
| Ghana | 0.42 | 0.06 | 4,296 | 8,793 | 16 | 12 | 1,922 |
| Malawi | 0.65 | 0.10 | 1,025 | 4,933 | 67 | 21 | 728 |
| Nigeria | 0.59 | 0.18 | 4,238 | 39,225 | 16 | 3 | 1,876 |
| Tanzania | 0.73 | 0.20 | 1,108 | 12,071 | 62 | 9 | 804 |
| South Korea | 0.07 | 0.03 | 22,882 | 78,180 | 3 | 1 | 21,701 |
| United States | 0.01 | 0.01 | 68,342 | 105,193 | 1 | 1 | 30,491 |

Note: Value-added (VA) is measured in constant 2005 US dollar purchasing power parity (PPP). The productivity gap is measured as the ratio of value-added per worker in the US relative to the value-added per worker in each country. Industry comprises manufacturing, construction, mining and quarry, and utilities.
Source: The 10-sector database published by the Groningen Growth and Development Center (GGDC).

growth, cereal yield remains relatively low in SSA, especially, in Nigeria and Tanzania. In 2012, the average yields in Tanzania and Nigeria were respectively 22% and 24% of the yield in the United States. Also, despite the significant growth in yield, the relative cereal yield declined over the past decades in all the SSA countries except in Ethiopia. The declined was particularly pronounced in Tanzania, where the relative yield declined from 32% in 1961 to 22% in 2012.

### 3.3.2 Inputs and Agricultural Research Expenditure in SSA

Aside from low labour productivity and the larger productivity gap in agriculture, farm mechanization, chemical inputs use, and spending on agricultural research and development also remain low in SSA. Table 3.3 presents information on farm machinery utilization (measured as

Table 3.2: Average cereal yield and growth in yield for the period 1961-2012

| | Cereal Crop Yield | | Relative to United States | | Average, 1961-2012 | |
|---|---|---|---|---|---|---|
| Category | 1961 | 2012 | 1961 | 2012 | Yield | Growth |
| Ethiopia | 715 | 2,047 | 0.28 | 0.35 | 1,117 | 2.06 |
| Ghana | 816 | 1,768 | 0.32 | 0.30 | 1,089 | 1.52 |
| Malawi | 984 | 2,087 | 0.39 | 0.35 | 1,234 | 1.47 |
| Nigeria | 743 | 1,401 | 0.29 | 0.24 | 1,111 | 1.24 |
| Tanzania | 806 | 1,315 | 0.32 | 0.22 | 1,155 | 0.96 |
| South Korea | 3,197 | 6,720 | 1.27 | 1.13 | 5,288 | 1.46 |
| United States | 2,522 | 5,925 | 1.00 | 1.00 | 4,620 | 1.67 |

Note: Cereal comprises wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains. Yield is defined as output (production) per hectare.
Source: World Development Indicators. Accessed on June 27, 2017.

Table 3.3: Agricultural machinery (tractors) and the rate of mechanization in SSA.

| | Agricultural tractor use (total number) | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Ethiopia[a] | Ghana | Malawi[b] | Nigeria | Tanzania[c] | South Korea | United States |
| 1961 | 250 | 1,000 | 198 | 500 | 16,550 | 24 | 4,690,000 |
| 1970 | 2,913 | 2,084 | 692 | 2,900 | 17,000 | 61 | 5,270,000 |
| 1980 | 3,356 | 2,004 | 692 | 8,400 | 10,000 | 2,664 | 4,726,000 |
| 1990 | 3,356 | 1,924 | 692 | 13,900 | 7,365 | 41,203 | 4,426,699 |
| 2000 | 3,356 | 1,944 | 692 | 19,400 | 16,300 | 191,631 | 4,503,625 |
| 2005 | 3,356 | 1,807 | 692 | 23,000 | 21,207 | 227,873 | 4,470,905 |
| | Agricultural tractor use (Per 100 square kilometre of arable land) | | | | | | |
| | Ethiopia[a] | Ghana | Malawi[b] | Nigeria | Tanzania[c] | South Korea | United States |
| 1961 | 0.2 | 6 | 2 | 0.2 | 32 | 0.1 | 260 |
| 1970 | 2 | 12 | 4 | 1 | 24 | 0.3 | 279 |
| 1980 | 3 | 11 | 4 | 4 | 13 | 13 | 250 |
| 1990 | 3 | 7 | 4 | 5 | 8 | 211 | 238 |
| 2000 | 3 | 5 | 4 | 6 | 19 | 1,115 | 257 |
| 2005 | 3 | 5 | 4 | 6 | 25 | 1,387 | 271 |

Note: Denotes the latest year for which data is available: [a]1972, [b]1968, [c]2002. Agricultural tractor is measured as the number of tractors in use.
Source: World Bank, World Development Indicators. Accessed on June 27, 2017.

the total number of farm tractors in-use) and the rate of farm mechanization (measured as the number of tractors per 100 square km of arable land) in SSA. In Ethiopia, Ghana, and Malawi, farm machinery (tractors) utilization and the rate of agricultural mechanization remains low. Between 1961 and 2005, less than a thousand additional units of tractors were put into use in Ghana and Malawi compared to about 4000 units in Tanzania and over 22000 units in Nigeria. The rate of farm mechanization also declined in Ghana from 6 tractors per 100 square km of arable land in 1961 to 5 tractors per 100 square km of arable land in 2005 and only increased marginally in Ethiopia, Malawi, and Nigeria over the same period. Even for Nigeria and Tanzania that had improved utilization of farm machinery, their rate of mechanization lags substantially behind that of South Korea or the United States. The rate of farm mechanization has been particularly impressive for South Korea, especially, since the 1990s.

Table 3.4 panel A presents information on fertilizer consumption in agriculture for the five SSA countries. fertilizer consumption is measured in kilograms per hectare of arable land (kgs per ha). A comparison across the SSA countries shows that fertilizer use in agriculture is much lower in Nigeria and Tanzania than the rest of the SSA countries. Also, whereas the average fertilizer use did increase in Ethiopia, Ghana, and Malawi over the period, it stagnated in the case of Nigeria and Tanzania. Nonetheless, when compared to South Korea or the United States, one sees that the use of fertilizer on farms is less widespread in SSA. These inputs are thus less intensively used in agriculture.

Table 3.4 panel B shows the use of insecticides, herbicides and pesticides

Table 3.4: Chemical use in agriculture

| | fertilizer consumption (kilograms per hectare) | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Ethiopia | Ghana | Malawi | Nigeria | Tanzania | South Korea | United States |
| 2002 | 17.01 | 3.75 | 29.71 | 4.53 | 3.70 | 412.13 | 112.52 |
| 2005 | 10.90 | 6.00 | 30.49 | 7.20 | 5.75 | 643.36 | 118.60 |
| 2010 | 21.85 | 18.84 | 35.38 | 6.20 | 6.57 | 336.06 | 122.99 |
| 2011 | 20.82 | 13.26 | 29.52 | 4.47 | 7.98 | 334.91 | 129.35 |
| 2012 | 23.76 | 34.94 | 39.89 | 4.77 | 4.40 | 481.01 | 131.11 |
| Year | Ethiopia | Ghana | Malawi | Nigeria | Tanzania | South Korea | United States |
| Insecticide | | | | | | | |
| 2000 | 38.00 | 47.00 | 257.00 | - | - | 8,625.00 | 100,243.83 |
| 2010 | 638.40 | 3,448.71 | 357.61 | - | - | 7,414.00 | 78,471.42 |
| Herbicide | | | | | | | |
| 2000 | 533.00 | 22.00 | 327.00 | - | - | 5,822.00 | 195,951.74 |
| 2010 | 3,109.70 | 9,979.25 | 43.40 | - | - | 5,224.00 | 200,487.66 |
| Pesticide | | | | | | | |
| 2000 | 602.00 | 81.63 | 632.47 | - | - | 25,684.00 | 430,005.21 |
| 2010 | 4,128.10 | 14,701.55 | 584.12 | - | - | 20,431.00 | 397,800.18 |

Note: Denotes the latest year for which data is available: [a]2009, [b]2007. Data on Nigeria and Tanzania are unavailable.
Source: Food and Agricultural Organization Statistics and the World Bank.

Table 3.5: Agricultural research expenditure and expenditure share in GDP

| | Agricultural Research Expenditure (2011 PPP$) | | | | | Agricultural Research Expenditure (% Share of Agr. GDP) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Ethiopia | Ghana | Malawi | Nigeria | Tanzania | Ethiopia | Ghana | Malawi | Nigeria | Tanzania |
| 2000 | 56.40 | 87.70 | 22.70 | 361.70 | 48.70 | 0.31 | 0.59 | 0.89 | 0.41 | 0.45 |
| 2005 | 87.60 | 117.90 | 17.90 | 575.80 | 35.60 | 0.38 | 0.58 | 0.77 | 0.31 | 0.25 |
| 2010 | 92.60 | 139.80 | 27.60 | 463.30 | 117.10 | 0.24 | 0.67 | 0.91 | 0.24 | 0.68 |
| 2011 | 87.20 | 139.00 | 32.60 | 550.10 | 97.70 | 0.20 | 0.69 | 1.03 | 0.29 | 0.54 |
| Percentage change (2000-2011) | 54.61 | 58.49 | 43.61 | 52.09 | 100.62 | -35.48 | 16.95 | 15.73 | -29.27 | 20.00 |

Source: Agricultural Science and Technology Indicators (ASTI) database published by the International Food Policy Research Institute (IFPRI). Accessed online on June 27, 2017.

in Ethiopia, Ghana and Malawi for 2000 and 2010. These chemical inputs are measured in tonnes of active ingredients. A similar pattern of low consumption is again observed for these chemical inputs use in SSA, especially, in Ethiopia and Malawi. In fact, in Malawi, pesticide and herbicide use declined over the period. Even though the use of herbicides and pesticides increased substantially between 2000 and 2010 in Ghana, they still lag behind that of South Korea and the United States. It must, however, also be noted that even though chemicals are "good" in some sense, they are also bad in many other ways. They lead to soil depletion of micronutrients, water contamination, acidification of the soil, and air pollution, and as such there are many "bad" things associated with them.

Table 3.5 shows the total government expenditure allocation to agricultural research and the share of the expenditure in agricultural GDP. Expenditure on agricultural research is highest in Nigeria and lowest in Malawi. Also, since the 2000s, greater expenditure allocation has been geared towards agricultural research in all countries, with the allocation doubling in Tanzania and increasing by over 50% in Ethiopia, Ghana, and Nigeria by 2011. Nonetheless, the share of research expenditure in agricultural GDP remains low in most of the SSA countries, accounting for less than 1% of agricultural GDP. In both Ethiopia and Nigeria, the share of research expenditure in agricultural GDP declined between 2000 and 2011.

### 3.3.3 Country-Specific Characteristics and Policies Towards Agriculture and Crops

This section provides a general overview of the agricultural sector in SSA with a major focus on national policies governing agriculture as well as land, geo-climatic conditions, and crop characteristics of each

Table 3.6: Agricultural land use for selected countries in SSA

| | Ethiopia | | Ghana | | Malawi | | Nigeria | | Tanzania | |
|---|---|---|---|---|---|---|---|---|---|---|
| Category | ('000' Ha) | (%) | ('000' Ha) | (%) | ('000' Ha) | (%) | ('000' Ha) | (%) | ('000' Ha) | (%) |
| Country Area | 110,430 | 100.00 | 23,854 | 100.00 | 9,428 | 100.00 | 92,377 | 100.00 | 94,730 | 100.00 |
| Agricultural Area | 36,259 | 32.83 | 13,628 | 57.13 | 5,735 | 60.83 | 70,800 | 76.64 | 39,650 | 41.86 |
| Cultivated Land | 16,259 | 44.84 | 7,847 | 57.58 | 3,750 | 65.39 | 40,500 | 57.20 | 15,650 | 39.47 |
| Under Irrigation (% of Cultivated Land) | 858 | 5.28 | 30 | 0.39 | 56 | 1.50 | 325 | 0.80 | 364 | 2.32 |
| Irrigation Potential | 2,700 | 16.61 | 1,900 | 24.21 | 162 | 4.32 | 2,331 | 5.75 | 2,132 | 13.62 |

Note: Year of observation in parenthesis: Ethiopia (2013); Ghana (2010); Malawi (2013); Nigeria (2013); Tanzania (2013). Source: Food and Agricultural Organization (FAO) AQUASTAT. Accessed on June 27, 2016.

country. Table 3.6 shows the distribution of land area for agriculture, under crop cultivation, and under irrigation for the countries under consideration. Below I review each country in turn.

### Ethiopia

Ethiopia, a landlocked country, lies in the north-eastern part of Africa. It has a total land area of 110.43 million hectares (est. in 2013) of which agricultural land accounts for only 33% (36.30 million hectares). Of the total agricultural land, cultivated land constitutes 45% (16.30 million hectares), and only 5.30% of the cultivated land is under irrigation despite the irrigation potential of 17%. The country has a vast topography that ranges from high mountains to flat-topped plateau, lowlands, and plains. Due to the low irrigation development, production and agricultural productivity is highly dependent on rainfall, which is highly erratic with long spells of dry and severe droughts. The climatic condition in Ethiopia is tropical monsoon, and there are three types of climatic zones (cool zone, temperate zone, and the hot lowlands) and agro-climatic zones (areas with little or no rainfall, areas with one rainy season, and areas with two rainy seasons). The main crops include coffee, oilseeds, cereals, cotton, sugar-cane, khat, spices, and cut flowers. Coffee is the largest export commodity and accounts for about 30% of the country's agricultural export earnings. Agricultural production is predominantly traditional, with commercial agriculture only emerging recently. Production is also dominated by small-farm holdings, and land holdings are highly fragmented (FAO, 2016).

Agriculture in Ethiopia is governed by the Agricultural Sector Policy and Investment Framework (Chanyalew, Adenew, and Mellor, 2010). This policy provides the framework for agriculture and agro-business. The policy among others is aimed at achieving sustainable production and productivity growth, accelerating agriculture commercialization and the proportion of marketed agricultural output, reducing land degradation, achieving universal food security, increasing private investment, diversifying into higher value products, and improving farmer access to modern inputs, finance, land, and irrigation. The policy is also targeted at increasing both the production of food and cash crops as well as livestock (Chanyalew et al., 2010).

### Ghana

Ghana is located in the west of Africa with a total land area of 22.75 million hectares (est. in 2010) of which agriculture accounted for almost 70% (15.70 million ha) in 2010. Approximately, 58% (7.8 million hectares) of the total agricultural land is currently under cultivation suggesting the potential for agricultural expansion in Ghana (Ghana, 2011). There are six agro-ecological zones in Ghana: the rainforest; deciduous forest; transition zone; Guinea Savannah; Sudan Savannah; and coastal Savannah. The sector produces 60% of the country's food supply and provides raw materials for the country's industrial sector. The principal agricultural products include industrial crops (such as cocoa, oil palm, kola, and rubber), starchy and cereal staples (such as cassava, yam, maize, and rice; and horticulture (such as fruits and vegetables such as pineapple, tomato, and pepper). Mono-cropping and mixed farming are the two dominant forms of farming. Similar to many African countries, agricultural production is heavily dependent on rainfall due to low irrigation. Only 0.40% of the total cultivated agricultural land is currently under irrigation despite an irrigation potential of 24%. Rainfall distribution varies considerably across regions and agro-ecological zones and is much higher in the southern belt (the rain-forest, deciduous forest, and the transition zones) than the northern belt (Guinea Savannah, Sudan Savannah, and coastal Savannah) (Ghana, 2011).

The Food and Agricultural Sector Development Policy II (FASDEP II) provides the framework for development and interventions in the agricultural sector in Ghana (Ministry of Food and Agriculture, 2007). This policy superseded FASDEP I which provided the framework for modernizing the agricultural sector and transforming the agrarian structure of the Ghanaian economy. The FASDEP II is aimed at enhancing the business environment and targeting the poor and risk-averse farmers. Specifically, the policy seeks to improve food security and income growth, increase agricultural competitiveness and enhanced market integration, achieve sustainable land management, apply science and technology to agricultural development, and improve institutional coordination. As a result, the policy is linked to several other national policies including the Growth and Poverty Reduction Strategy (GPRS II) and the Comprehensive Africa Agriculture Development Program (CAADP). The policy also iterates the government's commitment to allocating at least 10% of its annual budget to agriculture (Ministry of Food and Agriculture, 2007).

**Malawi**

Malawi is located in the Southern part of Africa with a total land area of 9.43 million hectares (est. in 2013) of which agriculture and land under cultivation constitute 60.80% and 65.40% respectively. The country is characterized by highlands, plateau, rift valley escarpment, and rift valley plains FAO (2016). The climatic condition in Malawi is mostly tropical continental (dry air mass) with two major farming seasons: the rainy season (November to April) and the dry season (May to October). Rapid population growth in recent years has led to pressure on the agricultural land use, and agricultural cultivation is now expanding to marginal and less fertile land. Rapid population growth has also reduced the fallow period for restoring soil fertility. Like many other African countries, agriculture is largely rain-fed as irrigation development is not widespread. As of 2002, only 2% (56,400 ha) of the total cultivated area is equipped for full or partial irrigation which is 60% below its potential of 161,900 ha. The country produces mostly maize crop, which accounts for about 90% of the total cultivated land. Other crops produce include sorghum, millet, pulses, rice, root crops, vegetables and fruits, cotton, groundnut, coffee, and tobacco (FAO, 2016).

The post-independence agricultural strategy in Malawi was focused on achieving food self-sufficiency and rapid economic growth. This led to many policy reforms in the sector in the 1980s including the removal of restrictions on burley tobacco production, inputs and output marketing controls. These reforms also led to price decontrols and the commercialization of parastatals. In the late 1990s, the government undertook another comprehensive review of all its agricultural policies and in 2007 formulated a sector-wide program to harmonize investment in the sector. The National Agricultural Policy was thus formulated to provide a coherent national agricultural policy (Ministry of Agriculture, Irrigation and Water Development, 2016). The policy is guided by a number of principles including the realignment of regional and international policies, institutional harmonization, and evidenced-based decision making. In line with the realignment of regional and international policies, the government is also committed to allocating 10% of its national budget to agriculture (Ministry of Agriculture, Irrigation and Water Development, 2016).

### Nigeria

Nigeria, with a total land area of 92.38 million hectares (est. in 2013), is located in the tropical zone of West Africa. Of the total land area, agriculture accounts for 76% (70.80 million ha) and a total of 40.5 million ha (57.20%) is under cultivation (FAO, 2016). Farming is mostly smallholder-based, and land holdings are highly fragmented. The country has three distinct ecological zones: the northern Sudan Savannah; the Guinea Savannah (Middle Belt); and the southern rain-forest. Agriculture in Nigeria is mostly rain-fed, and rainfall varies substantially across the different climatic zones. For example, the rainy season in the Southern belt lasts for 9-12 months compared to only 2-3 months in the northern zone. The country produces mostly rice, cassava, yam, maize, sorghum, millet, groundnut, cocoa, and sesame. However, due to vast differences in rainfall patterns and geo-climatic conditions, crop production varies across regions. The northern Savannah is suitable for sorghum, millet, maize, groundnut, and cotton. The middle and the southern belt produces mostly food crops (cassava, yam, plantain, maize, and sorghum) and cash crops (oil palm, cocoa, and rubber) (FAO, 2016).

Prior to the late 1960s, agriculture in Nigeria was highly neglected. Most government support was concentrated on export crops such as cocoa, groundnut, palm produce, rubber, and cotton. As a result, the sector experienced rapid deterioration in the 1970s and 1980s which was further compounded by severe droughts. Consequently, the government implemented several initiatives, and in 1985 adopted the Agricultural Policy to provide the framework for the sector from 1985-2000. The policy subsidizes selected farm inputs and equipment. Between 2011 and 2014, agriculture in Nigeria was governed by the National Agricultural Investment Plan (NAIP), with the aim of enhancing agricultural productivity through the application of modern technology and the diffusion of knowledge. Currently, the government has adopted the Agriculture Promotion Policy as part of its transformation agenda to provide the policy framework for agriculture from 2016-2020 (Federal Ministry of Agriculture and Rural Development, 2016). This policy is aimed at building an agri-business economy for Nigeria. Specifically, the policy provides guidance in reviving the agricultural sector, integrating agriculture into the global supply chain, promoting responsible land and water use, and improving agricultural governance. The policy also prioritizes improving productivity for selected food such as rice, wheat, maize, soya beans, fruits, and vegetables and export crops such as cowpea, cocoa, cashew, cassava, oil palm, and cotton (Federal Ministry of Agriculture and Rural Development, 2016).

## Tanzania

The United Republic of Tanzania consists of the mainland (Tanzania) and Zanzibar (the islands of Unguja and Pemba) and has an estimated land area is 94.73 million hectares (est. in 2013) of which agriculture accounts for about 42% (39.65 million hectares). Of the total agricultural land, cultivated area constitutes about 40% (15.65 million hectares), and only 2.30% (0.36 million hectares) is under irrigation despite the country's irrigation potential of 14% (1.36 million hectares) (FAO, 2016). The country is characterized by plains along the coast (tropical climate), a plateau in the central area, and highlands (temperate climate) in the north and south. Agriculture is predominantly rain-fed, and the rainfall distribution is either uni-modal (central, southern and south-western highlands) or bimodal (coastal belt, the north-eastern highlands, and the Lake Victoria Basin). Agriculture is dominated by smallholding farms, and commercial farming accounts for a little over 1000 farms (FAO, 2016). Crops produced include maize, dry beans, rice, sunflower, cassava, sorghum, groundnut, sweet potato, green coffee, tobacco, cashew nuts, cotton, sesame, and tea (FAO, 2016).

Macroeconomic factors have primarily influenced agricultural policy in Tanzania. Policies during the post-independence era emphasized improving peasant farming through the provision of extension services, credits, and marketing structures. This led to the heavy involvement of government in agriculture and agricultural activities were heavily controlled by the government. This, however, resulted in the stagnation of the sector and productivity in agriculture. Therefore, in 1983, the government adopted a new development policy for the agricultural sector. A series of policy modifications and adjustments were implemented in the late 1980s and early 1990s, which included the devaluation of the exchange rate, a reduction of subsidies to parastatal, elimination of price controls, and raising producer prices for exported crops. During this period, agriculture was brought into the tax base system and taxed at the central, regional and local levels. Taxes were also introduced on exports and commercial agricultural goods, and tax-based incentives were provided to investors in agriculture and agribusiness. In 1997, the government adopted the Agricultural and Livestock Policy (NALP 1997) to further address the challenges of the sector. The adoption of this policy ended the heavy government involvement in agriculture. The role of the government was re-focused to provide food security. The private sector was also made the engine of growth for agriculture in the areas of crop production, processing, and marketing. The National Agriculture Policy of 2013 (NAP 2013) is the latest policy framework for agriculture in Tanzania (Ministry of Agriculture, Food Security and Cooperatives, 2013). This policy is aimed at making the agricultural sector more efficient, competitive and profitable as part of the government's green revolution initiative and commitment to transforming agriculture from subsistence to commercial and a modernized sector

(Ministry of Agriculture, Food Security and Cooperatives, 2013).

In summary, while productivity in agriculture remains low in SSA by international standards, considerable efforts have been directed to addressing this issue in all five countries studied here with national policies providing the guiding framework for the agricultural sector. Most countries are characterized by uniform policies. At the heart of agricultural development is the emphasis on farm commercialization and modernization as the solutions to addressing the productivity menace in SSA. However, while all these policies emphasizes transforming agriculture from subsistence to commercial farming, none of the policies provides empirical evidence on the benefits of commercialization in raising productivity in agriculture. In the empirical analysis of the chapter, I provide direct estimate of the impact of farm commercialization on agricultural productivity and labour reallocation.

## 3.4 Methodology

This study uses econometric techniques to estimate production functions for farms, examine TFP, and estimate technical efficiency across the different farm types.[7] This approach permits one to estimate agricultural productivity and the underlying structural parameters of the production function separately for each farm type.

[7] The use of an econometric technique to study agricultural productivity is widely used. Readers are referred to Hayami and Ruttan (1970).

### 3.4.1 Model Specification

The market value of farm output $Q$ at farm $i$ depends on a factor-neutral technology parameter $A$; land $T$; labour $L$; capital (farm equipment and machinery) $K$; and chemical inputs $M$, measured as a composite of fertilizer, insecticide, and pesticide. While the use of market value does permit a linear aggregation of the dollar ($) value of different farm products, it nonetheless, does not fully take into account the riskiness of each crop type. While this seems to be a weakness, one can argue that the perceived riskiness of each crop type has been partially captured by output prices used in the market value computation. Hence, the use of market value does not pose a serious constraint.

In the empirical estimation, it is conventional to specify either a Cobb-Douglas or a translog production function. The study first specify a translog production function of the form

$$\begin{aligned} lnQ_i = \beta_0 + \beta_L lnL_i + \beta_T lnT_i + \beta_K lnK_i + \beta_M lnM_i + \left(\frac{1}{2}\right)\beta_{LL}(lnL_i)^2 + \\ \beta_{LT} lnL_i lnT_i + \beta_{LK} lnL_i lnK_i + \beta_{LM} lnL_i lnM_i + \left(\frac{1}{2}\right)\beta_{TT}(lnT_i)^2 \\ + \beta_{TK} lnT_i lnK_i + \beta_{TM} lnT_i lnM_i + \left(\frac{1}{2}\right)\beta_{KK}(lnK_i)^2 \\ + \beta_{KM} lnK_i lnM_i + \left(\frac{1}{2}\right)\beta_{MM}(lnM_i)^2 + \varepsilon_i, \end{aligned} \tag{3.1}$$

where $\varepsilon$ is the idiosyncratic error term. The translog specification permits any degree of substitution across inputs, such as the degree of substitution between capital and labour, labour and chemical input, or land and capital. It also places no a priori restrictions on cross-input elasticity of substitution unlike the Cobb-Douglas specification that imposes a unitary elasticity of substitution across inputs. The model can be estimated separately for each farm type, each with a different set of production parameters. Moreover, with the translog specification, one can statistically test the significance of the cross-input elasticities $\beta_{LT}$, $\beta_{LK}$, $\beta_{LM}$, $\beta_{TK}$, $\beta_{TM}$, $\beta_{KM}$, and conduct the relevant joint hypothesis test for a nested Cobb-Douglas. In a special case, when inputs are additive separable and $\beta_{ij} = 0, \quad \text{where} \quad i \neq j$, the translog specification reduces to a Cobb-Douglas of the form

$$lnQ_i = \beta_0 + \beta_L lnL_i + \beta_T lnT_i + \beta_K lnK_i + \beta_M lnM_i + \varepsilon_i. \qquad (3.2)$$

### 3.4.2 Measuring TFP across Farm Types

Farm-level TFP ($A_i$) is determined as the ratio of aggregate output to aggregate inputs and using growth accounting, the residual of output after accounting for all inputs use. In the empirical estimation of the production function, the farm-level TFP (in logs) is determined as the intercept of the production function and the random error term

$$A_i = \beta_0 + \varepsilon_i. \qquad (3.3)$$

The average is computed separately and compared across the subsistence and commercial farm types. To determine if the differences in TFP estimated across farm types are statistically significant or not, the study uses the dummy variable approach where a binary indicator for farm commercialization is included in the regression model. The dummy variable takes a value zero if the farm is classified as subsistence and one if the farm is commercial. The coefficient on the dummy variable, thus, measures the TFP difference between the commercial farm type and subsistence farm type.

### 3.4.3 Model Estimation

The production function is estimated using OLS and using constrained and unconstrained optimization techniques. The constrained optimization estimates the model under the assumption of constant returns to scale. The unconstrained technique, on the other hand, estimates the production function without placing any linear restrictions on the elasticity parameters and this permits a direct estimation of returns to scale. However, as argued by Olley and Pakes (1996) and Levinsohn and Petrin (2000), an OLS estimation of equation (3.2) and hence equation (3.3) could yield inconsistent (biased) results due to the potential correlation/endogeneity between the variable inputs such as $M$ and the unobserved farm-specific TFP in any given year. For instance, in years with plenty rainfall (a positive productivity "shock") farmers may use more variable inputs. To the extent that this is true, ordinary least squares (OLS) estimation of the production function would yield biased parameter estimates, and, by implication, biased total factor productivity estimates. The most common approach to addressing the endogeneity problem is to include a proxy for the unobserved farm-level productivity shocks and thus control for the part of the error term that is correlated with inputs. Specifically, let

$$\varepsilon_i = \omega_i + \eta_i, \tag{3.4}$$

so that $\varepsilon_i$ is assumed to be additive separable in observed $\omega_i$ and i.i.d. $\eta_i$ components. In this specification, whereas $\omega_i$ is a state variable and enters into the farmer's decision rules, $\eta_i$ has no impact on the farmer's decision. In the cross-sectional setting, the most common identification strategy is to directly include in the regression a set of controls for the determinants of total factor productivity (see for example Restuccia and Santaeulalia-Llopis, 2017; Gollin and Udry, 2019). This study adopts the direct estimation technique and estimates the production function by OLS after including controls for geo-climatic conditions (e.g. rainfall), farm characteristics (irrigation, and tractor use), land/plot characteristics (agro-ecological zone, soil quality, land ownership, and land topology), and farmer characteristics (age, sex, marital status and education of household heads). Also, since the dependent variable, the market value of farm output $Q$ is a product of price and quantity and many farms typically engaged in multi-cropping, the study also controls for different crop types. These set of controls included in the regression model thus either augment land or labour productivity.

### 3.4.4 Identifying Subsistence Farms using Farm Commercialization Rate

The empirical identification of a subsistence farm is a complex task, especially, given the multifaceted dimensions from both the input and output perspectives. Pingali and Rosegrant (1995) describe agricultural commercialization as a process that leads to higher market orientation, progressively substitute out non-traded inputs in favour of purchased inputs, and a gradual decline of integrated farming systems, replaced with highly specialized enterprises. The authors identify three types of farm systems based on their rate of commercialization: subsistence, semi-commercial and fully commercialized. In subsistence farming, the primary objective is that of food self-sufficiency. Farmers produce using mostly non-traded inputs and household labour. In semi-commercialized farms, the primary objective is that of generating surplus output, and farmers produce using both traded and non-traded farm inputs. In a fully commercialized agricultural system, profit maximization is the primary objective and farmers produces using predominantly marketed inputs. Von Braun (1995) further argues that agricultural commercialization goes beyond the production of cash crops or supplying surplus output to the market and can take a different form on both the output and input side of production. On the output side, it takes the form of increased marketable surplus and on the input side takes the form of increased use of purchased/commercial inputs. Nepal and Thapa (2009) describe the process as involving a shift away from subsistence production and replaced with an elaborate market-determined production and consumption system.[8]

While the existing literature uses diverse methods/indicators for measuring farm commercialization and defining a subsistence farm, this study follows one of the most common approaches adopted, among others, by Von Braun (1995) and Demeke and Haji (2014) and measures farm commercialization as the ratio of marketed output to the gross market value of farm output. Thus,

$$\text{Commercialization Rate} = \frac{\sum P_i S_{ij}}{\sum P_i Q_{ij}}.$$

In this expression, $S_{ij}$ denote the quantity of crop $i$ sold by farm $j$ evaluated at the average community price level ($P_i$), and $Q_{ij}$ is total quantity of crop $i$ produced by farm $j$. Farms with low commercialization rates (i.e. at the lower tail of the commercialization rate distribution) are classified as subsistence, and those with significantly high commercialization rates are classified as commercial farms. The benchmark model defines subsistence farms as constituting all farms with 0% commercialization rate. For robustness purposes, the study also conducts sensitivity analysis based on different commercialization rate thresholds.

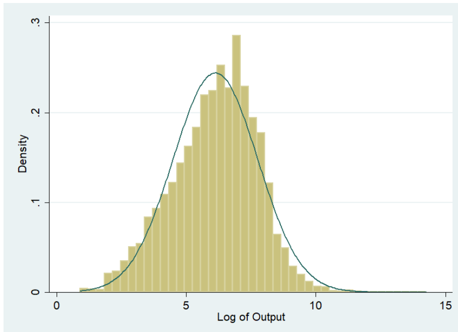
[8] Jaleta et al. (2009) provide a comprehensive review of the measurement of farm commercialization rates.

### 3.4.5 Data, Measurement of Variables, and Composition of Farms

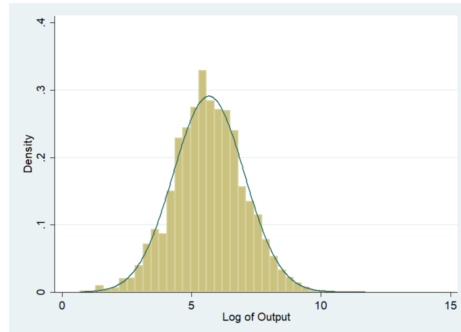
The data for the study is the Living Standard Measurement Survey - Integrated Surveys on Agriculture published by the World Bank. These are nationally representative cross-sectional household surveys. The survey defines a household as a person or a group of persons, who live together in the same dwelling, share the same house-keeping arrangements and are catered for (looked after) as one unit. The study draws on surveys from five SSA countries (survey years in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13). The nice feature of this survey is its focus on agriculture. The surveys collect detailed plot-level data on land/field use, crops, outputs, and labour (family and hired) and non-labour (such as fertilizers, herbicides, pesticides) inputs, and for both major (rainy) and minor (dry) seasons. In this regard, a "household" may own one or more parcels of land, and with each parcel containing one or more plots/fields. The plot is the primary unit of analysis and plots and farms are used interchangeably. Thus, a household member may own one or more plots/farms.

The main variables of interest are output, land, labour, capital, a measure of composite chemical inputs, and a set of information on access to irrigation, tractor use, crop types, agro-ecological zone, soil quality, land ownership, land topology, and household head characteristics

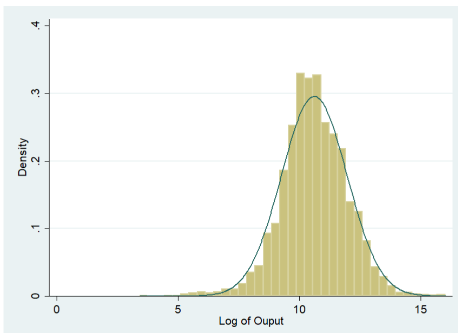
Figure 3.1: Distribution of the log market value of farm products (output)



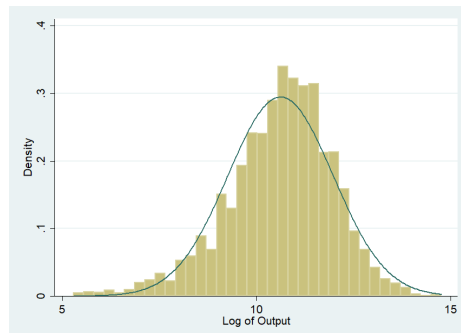

(a) Ethiopia



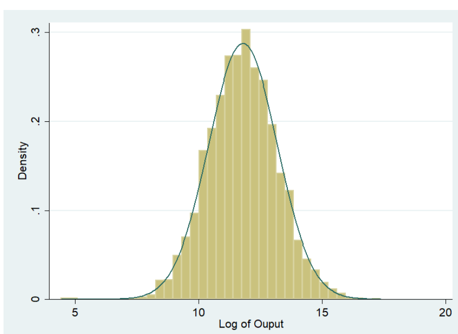

(b) Ghana




(c) Malawi




(d) Nigeria




(e) Tanzania

Note: Value of output in local currency unit is converted into common currency using the PPP US Dollar exchange rates.
Source: Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013), and Tanzania (2012/13).

such as age, sex, marital status and education. Output is measured as the market value of all farm products. Market value differs from sales or revenue since not all the crops produced by the farmer are sold in the market; some are consumed directly by the household. Figure 3.1 shows the distribution of market value of farm output (in logs). Labour included the total amount of family and hired labour, both on a permanent and casual basis. This variable is measured in total hours per year adjusted for differences in hours worked per day. Land is the size of a cultivated plot in hectares. Physical capital in agriculture entails the use of farm machinery and equipment. However, the data shows little use of farm machinery on most plots/farms. The primary farm-tools are cutlasses and hoes but have low to zero market values. Therefore, the study uses a self-assessed market value of land at the plot-level to control for "credit constraints". Most lending institutions (banks, credit unions, micro-finance) require some form of collateral for loan advancement, and for the majority of poor farming households, farmland is the only property they can use to secure a loan.[9] Alternative specifications altogether exclude capital from the production function and TFP estimations. The composite chemical input comprises mostly fertilizer use and its measured in kilograms (Kg); there is little or low use of insecticides and pesticides. The appendix provides a full description of the survey data-set and detailed explanation on the measurement of inputs and construction of the control variables.

Table 3.7 shows the distribution of farms based on the proportion of the value of output sold in the market. The analysis indicates a substantial proportion of farms, especially, in Ethiopia (90%), Malawi

[9] In the sample, the value of land and plot/farm sizes are not highly correlated. For example, the correlation coefficient ranges from 0.02 (in Ethiopia) to 0.19 (in Ghana)

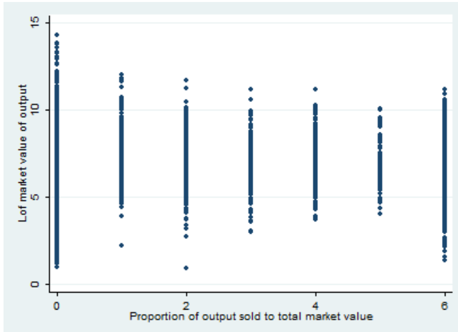
Table 3.7: Distribution of farms by percentage (%) of marketed output

| | Ethiopia | | Ghana | | Malawi | | Nigeria | | Tanzania | |
|---|---|---|---|---|---|---|---|---|---|---|
| Percent of Value of Output Sold | Farms | % | Farms | % | Farms | % | Farms | % | Farms | % |
| 0% | 17,848 | 88 | 1,607 | 34 | 4,075 | 68 | 2,701 | 55 | 3,107 | 59 |
| 0% - 20% | 666 | 3 | 284 | 6 | 659 | 11 | 458 | 9 | 334 | 6 |
| 20% - 40% | 521 | 3 | 439 | 9 | 278 | 5 | 473 | 10 | 361 | 7 |
| 40% - 60% | 316 | 2 | 518 | 11 | 238 | 4 | 429 | 9 | 364 | 7 |
| 60% - 80% | 228 | 1 | 557 | 12 | 163 | 2.7 | 359 | 7 | 291 | 6 |
| 80% - 90% | 82 | 0.4 | 280 | 6 | 62 | 1.0 | 131 | 3 | 126 | 2 |
| 90% - 100% | 571 | 3 | 1,026 | 22 | 560 | 9 | 397 | 8 | 653 | 12 |
| Total Farms | 20,232 | 100 | 4,711 | 100 | 6,035 | 100 | 4,948 | 100 | 5,236 | 100 |

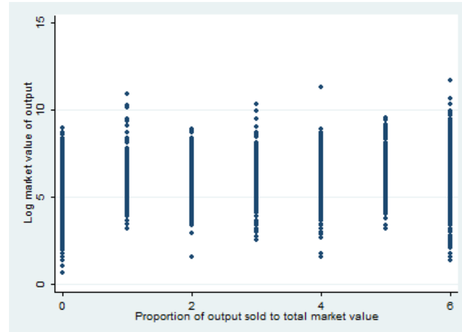
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

(70%), and Tanzania (60%) with no market orientation. These farms do not participate in the commercial output market, and production is strictly for household consumption. The highly commercialized farms (i.e. farms selling 80% or more of farm output) in these countries are less than 15%. In Nigeria, about 50% of farms produce strictly for home consumption, and the highly commercialized farms constitute about 10% of the sample. In Ghana, only 34% of the farms report no market orientation; the highly commercialized farms constitute almost 30% of the total number of farms. Figure 3.2 further shows a scatter plot of log output value to the proportion of the value of total output sold. The figure shows no systematic relation between farm size, log value of market output, and the degree of far commercialization. The distribution of farm output (in logs) is reasonably comparable across farms with different commercialization rates.

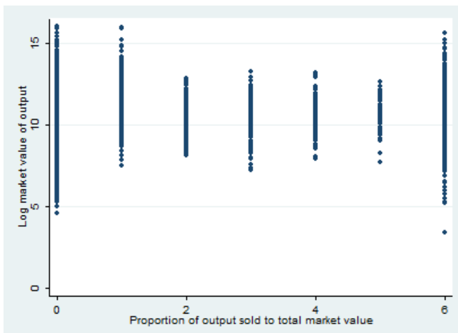
Figure 3.2: Total market value of farm output and value of output sold



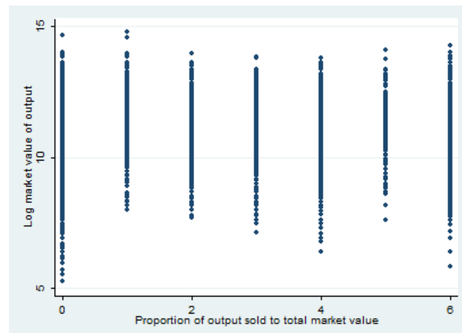

(a) Ethiopia



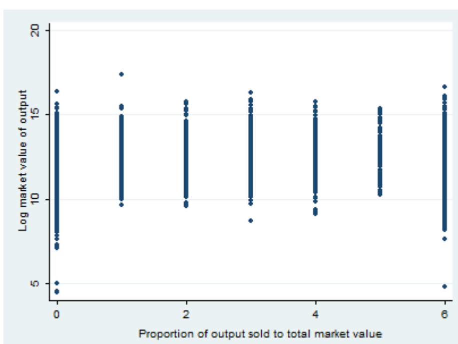

(b) Ghana




(c) Malawi




(d) Nigeria




(e) Tanzania

Note: The indexes 0, 1, 2, 3, 4, 5 and 6 denote farms with 0%, 0-20%, 20-40%, 40-60%, 60-80%, 80-90%, and 90-100% commercialization rates respectively.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

The sample consists of all households and farms that reported agricultural (farming) activity for the immediate past season. Table 3.8 shows the composition and distribution of households and farms by

Table 3.8: Distribution of households and farms by size and type

| | Farm Type | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ethiopia | | Ghana | | Malawi | | Nigeria | | Tanzania | |
| Category | Subs. | Comm. | Subs. | Comm. | Subs. | Comm. | Subs. | Comm. | Subs. | Comm. |
| Number of Farms | 17,848 | 2,384 | 1,607 | 3,104 | 4,075 | 1,960 | 2,701 | 2,247 | 3,107 | 2,129 |
| % of Farms | 0.88 | 0.12 | 0.34 | 0.66 | 0.68 | 0.32 | 0.55 | 0.45 | 0.59 | 0.41 |
| Number of Households | 1,732 | 1,419 | 598 | 1,933 | 1,561 | 1,441 | 1,244 | 1,486 | 1,130 | 1,734 |
| % of Households | 0.55 | 0.45 | 0.24 | 0.76 | 0.52 | 0.48 | 0.46 | 0.54 | 0.39 | 0.61 |
| % of Farmland | 0.76 | 0.24 | 0.26 | 0.74 | 0.66 | 0.34 | 0.48 | 0.52 | 0.42 | 0.58 |
| | Farm Size | | | | | | | | | |
| Category | Small | Large | Small | Large | Small | Large | Small | Large | Small | Large |
| Number of Farms | 20,100 | 132 | 3,759 | 952 | 6,004 | 31 | 4,721 | 227 | 4,449 | 787 |
| % of Farms | 0.99 | 0.01 | 0.80 | 0.20 | 0.99 | 0.01 | 0.95 | 0.05 | 0.85 | 0.15 |
| Number of Households | 2,717 | 434 | 1,346 | 1,185 | 2,868 | 134 | 2,372 | 354 | 1,980 | 884 |
| % of Households | 0.86 | 0.14 | 0.53 | 0.47 | 0.96 | 0.04 | 0.87 | 0.13 | 0.69 | 0.31 |
| % of Farmland | 0.75 | 0.25 | 0.45 | 0.55 | 0.96 | 0.04 | 0.69 | 0.31 | 0.38 | 0.62 |

Note: The benchmark defines subsistence as constituting any farm that consumes 100% of its total output. A small farm, on the other hand, is defined as a farm of size 2 hectares or less.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

types and sizes. Farms are categorized into small, large, subsistence, and commercial. The total number of farms is the headcount of all plots/farms. Subsistence is defined in its pure form and comprises farms that produce strictly for home consumption i.e. farms with 0% commercialization rate. On the other hand, a farm is classified as small if the size of the cultivated farmland is two hectares or less and a "household" is considered a "small-holder" if the total cultivated farmland by the household is two hectares or less. The proportion of farmland is determined as the ratio of total farmland by farm type or size to the total cultivated farmland. A comparison across farms shows that small and subsistence farms constitute a significant proportion of farms in most countries. In Nigeria and Tanzania, the un-weighted estimates show that subsistence farms constitute about 60% of the sample (total farms). In Malawi, subsistence farms constitute about 70% of the sample and in Ethiopia about 90%. The population-weighted estimates are much larger.[10] In Ethiopia, for example, subsistence farms constitute almost the entire sample and about 80% of the total farms in Malawi. In Ghana, subsistence farms constitute a little over 30% of the sample, and the weighted estimate is about 20%. On the other hand, a comparison across small and large farms shows that small farms constitute about 80% of the sample in all countries and the population-weighted estimates are also much higher.

A comparison of the proportion of plots/farms with no market orientation to the proportion of households with no market orientation is suggestive that the lack of commercialization is less of a problem at the household-level than at the plot-level, nonetheless still pronounced. In Ethiopia, about 45% of the households are commercially oriented compared to only 12% at the farm/plot level. In Malawi, it is 50% for households compared to 30% for plots/farms and in Tanzania, it is 60% for households compared to 40% at the plot-level. This evidence thus shows that the lack of commercialization is a choice rather than a lack of market knowledge or "access". Moreover, in most SSA countries, it is a common practice for households to use specific plots/farms to cultivate stable crops for home consumption and others to produce cash crops for commercial purposes. Thus, even though at the micro-level

[10] The population-weighted estimates take into account the weight of each farm type in the overall population.

Table 3.9: A cross tabulation of across farm types and sizes

| Country | Ethiopia | Ghana | Malawi | Nigeria | Tanzania |
|---|---|---|---|---|---|
| Proportion of Subsistence Farms which are Small | 1.00 | 0.88 | 0.99 | 0.96 | 0.90 |
| Proportion of Small Farms which are Subsistence | 0.88 | 0.37 | 0.68 | 0.55 | 0.63 |
| Proportion of Commercial Farms which are Large | 0.02 | 0.24 | 0.01 | 0.06 | 0.23 |
| Proportion of Large Farms which are Commercial | 0.38 | 0.79 | 0.32 | 0.56 | 0.61 |

Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

a farm may show up as subsistence, at the household level, the farm may appear commercial as long as a plot within the household parcel reports positive sales. Thus, the study uses a plot as the primary unit of analysis in order to overcome this challenge.

A further cross tabulation across farm types and sizes (presented in Table 3.9) shows that, whereas in Ghana, Nigeria and Tanzania, about 10% of subsistence farms are large farms, in Ethiopia and Malawi, almost all subsistence farms are small farms. On the other hand, only 40% of the small-size farms in Ghana are subsistence. In Ethiopia, small farms with no market orientation (i.e. pure subsistence) constitute almost 90% of the sample for small farms, and about 60% in Nigeria and Tanzania. By contrast, large commercial farms constitute less than 10% of the sample in Ethiopia, Malawi and Nigeria. In fact, in Ethiopia and Malawi, almost the entire commercial sample is comprised of small farms. In Ghana and Tanzania, these farms constitute a little over 20% of the commercial sample. On the other hand, in Ethiopia and Malawi, 40% of the sample for large-scale farms also produce with commercial orientation . In Ghana, a significant proportion of large farms produce

Table 3.10: Summary statistics on output, conventional inputs use, and productivity measures

| Country | Ethiopia | Ghana | Malawi | Nigeria | Tanzania |
|---|---|---|---|---|---|
| Number of Plots per Household | 6.40 | 1.90 | 2.00 | 1.80 | 1.80 |
| Plot Size (Hectares) | 0.19 | 1.43 | 0.36 | 0.56 | 1.27 |
| Labour per Farm (Man-Hours) | 29.94 | 137.97 | 41.04 | 239.21 | 80.03 |
| Family labour (% of Total Labour) | 78.00 | 53.00 | 88.00 | 88.00 | 88.00 |
| Labour on Subsistence Farms (% of Total Farms) | 80.00 | 24.00 | 64.00 | 51.00 | 49.00 |
| Land-Labour Ratio | 0.01 | 0.03 | 0.01 | 0.01 | 0.02 |
| Labour per Hectare | 2,153.00 | 155.00 | 215.00 | 1,994.00 | 173.00 |
| Proportion of Farms Reporting: | | | | | |
| Irrigation Use (%) | 3.61 | 4.49 | 0.93 | 1.42 | 2.19 |
| Use of Purchased / Rented Farm Land (%) | 18.51 | 18.80 | 15.36 | 13.45 | 16.56 |
| Right to Sell or Use Land as Collateral (%) | 91.26 | 49.52 | 55.33 | 70.78 | 89.22 |
| | | | | | |
| Market Value of Output per Farm ($ PPP) | 441.00 | 1,130.00 | 1,479.00 | 1,122.00 | 693.00 |
| Land Productivity ($ PPP) | 36,267.00 | 1,019.00 | 5,851.00 | 5,156.00 | 1,030.00 |
| Labour Productivity ($ PPP) | 40 | 21.00 | 50.95 | 12.89 | 11.96 |
| | | | | | |
| % of Farms using fertilizer on Plots | 52.30 | 25.34 | 61.13 | 40.74 | 22.57 |
| Quantity of fertilizer per Farm (Kg) | 46.09 | 150.44 | 403.09 | 198.71 | 676.43 |
| fertilizer per Hectare (Kg) | 2,103.00 | 166.00 | 2,614.00 | 801.00 | 1,528.00 |
| Cost of Chemical Input per Farm ($ PPP) | 115.00 | 146.00 | 264.00 | 156.00 | 191.00 |
| Cost of Chemical Input per Hectare ($ PPP) | 1,432.00 | 141.00 | 1,326.00 | 576.00 | 53.00 |

Notes: Productivity and costs estimates in local currencies have been converted into common currency using the 2010 PPP US dollars.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

with a commercial orientation. They constitute almost 80% of the large farm sample. In Nigeria and Tanzania, large farms which are commercial constitute over 50% of the large farm sample.

### 3.4.6 Measuring Productivity across Farm Types

Table 3.10 presents summary statistics on output, land and non-land inputs use, and farm productivity (land and labour) for the pooled sample. To aid the comparison across countries, output, productivity, and cost values in local currencies are converted into common currency units using the 2010 US dollars purchasing power parity (PPP). The reported statistics for each variable is obtained by taking a simple average across all farms in each country. For example, the reported labour ($L$) statistic is obtained by taking a simple average of labour used (in total hours per year) across all farms for a given year. It is, therefore, a measure of the average amount of labour used on a typical farm. Land and labour productivities are determined as the ratio of market value of output to a hectare of farmland and labour respectively. These measures are first calculated for each farm. A simple average across all farms is then determined and reported in Table 3.10. They are, therefore, measures of production efficiency by a typical farm. The analysis is similar for the rest of the reported measures such as land-labour ratio, labour per hectare, revenue per hectare, revenue per labour, and chemical inputs per hectare.[11]

The analysis indicates considerable differences in average input use and farm productivity across countries. The average number of plots per household is approximately two for Ghana, Malawi, Nigeria, and Tanzania compared to six for Ethiopia. Also, the average plot size is the largest in Ghana (1.43 ha) and lowest in Ethiopia (0.19 ha); the average plot size in Ghana is eight times larger than the average plot size in Ethiopia. Moreover, less than 20% of the farms reported operating on purchased or rented farmlands, and irrigation systems are underdeveloped; a large number of farms reported having no other source

[11]The inverse of the land-labour ratio is not the same as labour per hectare since the latter is based on a simple average across all farms.

of irrigation aside from rainfall. Less than 5% of farming households reported using irrigation, and this is much lower in Malawi and Nigeria. Concerning non-land input, average labour per farm use is the highest for Nigeria and lowest for Ethiopia; a typical farm in Nigeria uses about eight times more labour per farm than in Ethiopia. Also, except for Ghana, the use of family labour for crop production is typically high; about 90% in Malawi, Nigeria, and Tanzania and 80% in Ethiopia. Also, the proportion of farm labour allocated to subsistence farming is substantially higher in Ethiopia (about 90%) than the rest of the sample.

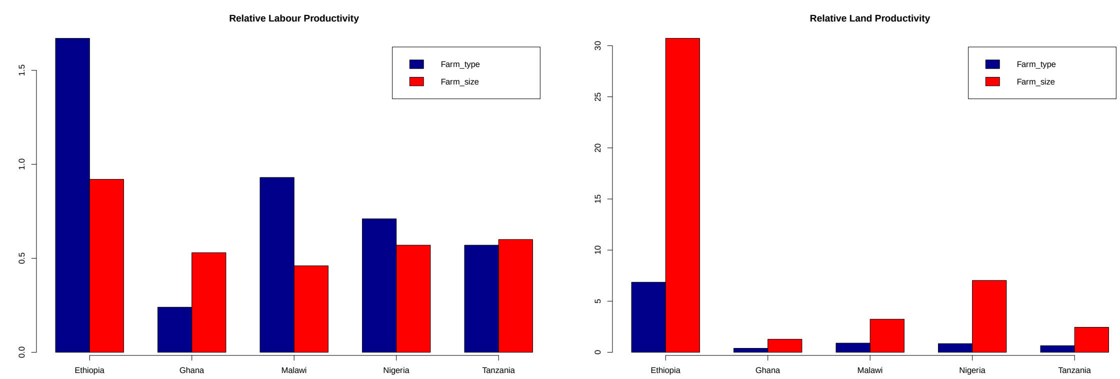
Nonetheless, farms in Ethiopia use labour more intensively than the farms in Ghana, Malawi, Nigeria or Tanzania. Labour per hectare is about 14 times higher in Ethiopia than in Ghana and 12 times higher in Ethiopia than in Tanzania. Also, the average fertilizer use per farm is the highest for Tanzania and lowest for Ethiopia. However, the average fertilizer use per hectare relatively is higher for Ethiopia and Malawi compared to the rest of the countries. For example, fertilizer use per hectare is more than ten times higher in Ethiopia and Malawi than in Ghana. Also, whereas in Ethiopia and Malawi, about 50% of farms reported using fertilizer, only a quarter of farms in Ghana and Tanzania reported fertilizer use on plots. Also, the average output per farm is much lower in Ethiopia and Tanzania than the rest of the countries. However, while land productivity remains high in all countries, it is substantially higher in Ethiopia than the rest of the sample due to the

Table 3.11: Comparison of productivity and input use across farm types and sizes

| | Subsistence Relative to Commercial Farms | | | | | Small Relative to Large Farms | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Category | ETH | GHA | MWI | NGA | TZA | ETH | GHA | MWI | NGA | TZA |
| Farm-Size (Hectares) | 0.42 *** | 0.68 *** | 0.93 *** | 0.76 *** | 0.50 *** | 0.02 *** | 0.21 *** | 0.14 *** | 0.11 *** | 0.11 *** |
| Labour per Farm (Man-Hours) | 0.54 *** | 0.62 | 0.84 *** | 0.86 *** | 0.65 *** | 0.06 *** | 0.30 *** | 0.63 *** | 0.71 *** | 0.42 *** |
| Land-Labour Ratio | 0.74 | 0.57 *** | 1.14 *** | 1.28 | 0.82 ** | 0.03 *** | 0.34 *** | 0.12 *** | 0.09 *** | 0.23 *** |
| Labour per Hectare | 5.06 * | 1.26 *** | 1.11 | 1.22 ** | 1.19 *** | 16.89 | 2.23 *** | 8.18 * | 18.98 *** | 4.35 *** |
| | | | | | | | | | | |
| Market Value per Farm ($ PPP) | 0.57 *** | 0.26 *** | 0.79 *** | 0.57 *** | 0.32 *** | 0.09 *** | 0.27 *** | 0.29 *** | 0.45 *** | 0.23 *** |
| Land Productivity ($ PPP) | 6.86 | 0.39 *** | 0.90 | 0.85 *** | 0.65 *** | 30.72 | 1.28 * | 3.24 | 7.03 *** | 2.45 *** |
| Labour Productivity ($ PPP) | 1.67 | 0.24 *** | 0.93 | 0.71 *** | 0.57 *** | 0.92 | 0.53 *** | 0.46 | 0.57 *** | 0.60 *** |
| | | | | | | | | | | |
| Quantity of fertilizer per Farm (Kg) | 1.35 | 2.68 *** | 0.41 *** | 0.89 | 0.69 * | 0.27 *** | 0.89 | 0.84 | 0.57 *** | 0.53 *** |
| fertilizer per Hectare (Kg) | 12.74 | 3.11 *** | 1.10 | 1.25 ** | 1.41 | 54.73 | 3.93 *** | 14.01 | 7.65 *** | 5.92 ** |
| Cost of Chemical Input per Farm ($ PPP) | 0.76 *** | 0.68 *** | 0.73 *** | 0.71 *** | 0.59 *** | 0.17 *** | 0.43 *** | 0.30 *** | 0.58 *** | 0.26 *** |
| Cost of Chemical Input per Hectare ($ PPP) | 2.10 | 0.76 | 1.29 | 0.93 | 0.64 *** | 9.87 | 2.31 *** | 3.86 | 7.61 *** | 1.88 ** |

Note: This table report ratios. Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

Figure 3.3: Relative land and labour productivity by farm-type and farm-size




(a) Relative labour productivity

(b) Relative land productivity

Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

small plot/farm sizes.

Table 3.11 examines land/labour productivity and input use across farm types and sizes. The table reports the ratio of means of land and labour productivity and inputs use for subsistence farms relative to commercial farms and for small farms relative to large farms. Tables

B.1 through to B.5 in the appendix report the summary statistics for each country. The analysis shows considerable differences in average inputs use and farm productivity across the farm categories. The average plot size and labour per farm are typically higher for commercial farms than subsistence farms. For example, in Ethiopia, the average plot size for subsistence farms is about 40% the size for commercial farms, and labour per farm is about 50% the size for commercial farms. On the other hand, labour per hectare and fertilizer per hectare are higher in subsistence farms than commercial farms. For example, in Ethiopia, labour per hectare is about five times higher in subsistence farms than commercial farms, and fertilizer per hectare is 12 times higher in subsistence farms than commercial farms. In Ghana, subsistence farms use about 30% more labour per hectare than commercial farms, and the ratio of fertilizer per hectare in subsistence to commercial farms is about 3 to 1.

Nonetheless, the average market value of output, land productivity (output per hectare), and labour productivity (output per labour) are typically higher for commercial farms than subsistence farms. The only exception is Ethiopia. In Ghana, land productivity for the commercial farm is about twice the size for a subsistence farm, and labour productivity for the subsistence farm is only 20% the size for a commercial farm. The analysis is similar for Malawi, Nigeria, and Tanzania. In Ethiopia, by contrast, land and labour productivity are substantially higher for subsistence farms than commercial farms.

A similar comparison across farms of different sizes shows that in all countries, the average plot size, non-land inputs use (labour and fertilizer), and labour productivity are lower in small farms than in large farms. However, land productivity, labour per hectare and fertilizer use per hectare are typically higher in small farms than large farms. Figures 3.3a and 3.3b plot the country-specific relative land and labour productivity across farm types and sizes.

## 3.5 Empirical Analysis

This section presents the result of the empirical econometric analysis. Section 1 presents the result of the production function estimation across farm types. Section 2 reports farm-level TFP differences estimates. Section 3 reports the results of technical efficiency across subsistence and commercial farm types. Section 5 concludes with a quantitative assessment of farm commercialization for labour reallocation away from agriculture to non-agriculture in SSA.

### 3.5.1 Characterizing the Production Function for Farms in SSA

To make inferences about the scale of production and production efficiency, the study characterizes the production technology of farms and separately for subsistence and commercial farms. I report robust standard errors clustered at the household level. Land parcels in most SSA countries are family owned, and household members operate on a common parcel of traditional/customary land. Consequently, geo-climatic conditions are similar across farms on the same parcel of land. The study first estimates the production function for the translog specification. Table 3.12 presents the results for the pooled sample and Table 3.13 reports the net input elasticities evaluated at the sample means for the three traditional inputs, labour, land and chemical (fertilizer). In most cases, the output elasticity of inputs are positive and statistically significant at the 1% level. Similarly, except in Tanzania, the net input elasticity estimates are positive and fairly comparable to those obtained based on the Cobb Douglas specification. However, most of the cross-input elasticities, particularly, in the case of Ghana, Malawi, and Tanzania, are not statistically significant. Table 3.14 further tests the significance of the joint cross-input elasticities for a nested Cobb-Douglas. The test rejects the translog specification in favour of a nested Cobb Douglas specification in Ghana and Tanzania. In both countries, the null of $\beta_{LT} = \beta_{LM} = \beta_{TM} = 0$ could not be rejected at the 5% significance level. The null hypothesis is rejected in Ethiopia, and in the case Malawi and Nigeria, the F test statistic (though rejects the null) is fairly weak.

Table 3.15 presents the output elasticity of inputs estimates for the parsimonious Cobb-Douglas specification. The result shows that elasticity estimates for the traditional (conventional) inputs $L$, $T$, $M$ are positive and statistically significant at the 1% significance level. A

Table 3.12: Translog estimation of the production function for all farms

| Dependent Variable: | Ethiopia | | | | Ghana | | | | Malawi | | | | Nigeria | | | | Tanzania | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Log Output Value | 1 | | 2 | | 1 | | 2 | | 1 | | 2 | | 1 | | 2 | | 1 | | 2 | |
| | Coeff | SE | Coeff | SE | Coeff | SE | Coeff | SE | Coeff | SE | Coeff | SE | Coeff | SE | Coeff | SE | Coeff | SE | Coeff | SE |
| Labour | 0.67 *** | 0.05 | 0.62 *** | 0.04 | 0.41 *** | 0.09 | 0.39 *** | 0.08 | 0.07 | 0.18 | -0.32 ** | 0.14 | 0.21 ** | 0.08 | 0.18 *** | 0.06 | 0.46 *** | 0.14 | 0.37 *** | 0.09 |
| Land | 0.35 *** | 0.04 | 0.46 *** | 0.04 | 0.24 ** | 0.09 | 0.42 *** | 0.09 | 0.66 *** | 0.15 | 1.05 *** | 0.14 | 0.42 *** | 0.07 | 0.79 *** | 0.08 | 0.28 *** | 0.10 | 0.53 *** | 0.08 |
| Chemicals | 0.26 *** | 0.06 | -0.08 *** | 0.03 | 0.26 *** | 0.07 | 0.19 *** | 0.05 | 0.25 *** | 0.06 | 0.27 *** | 0.04 | -0.06 | 0.05 | 0.03 | 0.04 | 0.11 ** | 0.05 | 0.10 *** | 0.03 |
| Labour × labour | -0.04 *** | 0.01 | -0.05 *** | 0.01 | -0.04 * | 0.02 | -0.03 * | 0.02 | 0.03 | 0.04 | 0.14 *** | 0.03 | -0.00 | 0.02 | 0.01 | 0.01 | 0.04 ** | 0.02 | 0.03 * | 0.02 |
| Labour × Land | 0.05 *** | 0.01 | 0.04 *** | 0.01 | 0.05 ** | 0.02 | 0.02 | 0.02 | -0.04 | 0.03 | -0.13 *** | 0.03 | 0.00 | 0.01 | -0.03 *** | 0.01 | 0.02 | 0.02 | -0.04 ** | 0.02 |
| Labour × Chemicals | -0.03 *** | 0.01 | 0.01 | 0.01 | -0.01 | 0.01 | 0.02 | 0.01 | -0.01 | 0.01 | -0.01 | 0.01 | -0.01 | 0.01 | 0.02 ** | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Land × Land | 0.03 *** | 0.01 | 0.03 *** | 0.01 | 0.00 | 0.04 | -0.05 ** | 0.02 | 0.12 *** | 0.03 | 0.11 *** | 0.03 | 0.05 *** | 0.02 | 0.06 *** | 0.02 | -0.02 | 0.03 | 0.00 | 0.02 |
| Land × Chemicals | 0.00 | 0.01 | -0.07 *** | 0.01 | 0.00 | 0.01 | 0.03 ** | 0.01 | 0.03 *** | 0.01 | 0.02 ** | 0.01 | -0.03 *** | 0.01 | -0.03 *** | 0.01 | -0.00 | 0.01 | 0.03 *** | 0.01 |
| Chemicals × Chemicals | -0.01 | 0.02 | 0.06 *** | 0.01 | -0.04 *** | 0.01 | -0.05 *** | 0.01 | -0.01 | 0.01 | -0.01 ** | 0.01 | 0.06 *** | 0.01 | 0.01 | 0.01 | -0.01 | 0.01 | -0.04 *** | 0.01 |
| N | 17,987 | | 17,987 | | 4,675 | | 4,675 | | 5,236 | | 5,236 | | 4,580 | | 4,580 | | 5,214 | | 5,214 | |
| $\bar{R}^2$ | 0.56 | | - | | 0.43 | | - | | 0.33 | | - | | 0.36 | | - | | 0.43 | | - | |
| RMSE | 1.08 | | 1.0877 | | 1.03 | | 1.04 | | 1.11 | | 1.12 | | 1.10 | | 1.15 | | 1.05 | | 1.06 | |

Note: All regressions in include controls for geo-climatic conditions, credit constraint (land value) farm (irrigation, farm-tool type, tractor use, crop type), land (ecological zones, soil quality, land ownership, land topology); and household characteristics (age, sex, marital status and education of household head). Robust standard errors clustered at the household level are in parentheses. Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
1 Denotes unconstrained model.
2 Denotes constrained model.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

Table 3.13: Net input elasticity estimates

| Dependent Variable: | Ethiopia | | Ghana | | Malawi | | Nigeria | | Tanzania | |
|---|---|---|---|---|---|---|---|---|---|---|
| Log Output Value | ( 1 ) | ( 2 ) | ( 1 ) | ( 2 ) | ( 1 ) | ( 2 ) | ( 1 ) | ( 2 ) | ( 1 ) | ( 2 ) |
| Labour | 0.31 | 0.44 | 0.17 | 0.32 | 0.17 | 0.28 | 0.13 | 0.37 | 0.69 | 0.53 |
| Land | 0.49 | 0.26 | 0.51 | 0.64 | 0.60 | 0.59 | 0.26 | 0.44 | 0.34 | 0.59 |
| Chemicals | 0.10 | 0.29 | 0.02 | 0.03 | 0.13 | 0.12 | 0.21 | 0.19 | 0.08 | -0.12 |
| $\sum$ Inputs | 0.90 | 1.00 | 0.70 | 1.00 | 0.89 | 1.00 | 0.60 | 1.00 | 1.12 | 1.00 |

1 Denotes unconstrained model.
2 Denotes constrained model.

within-country comparison shows that in Ghana, Malawi, and Nigeria, the elasticity estimate is particularly strong for land, and in Ethiopia and Tanzania, stronger for labour. The estimate for the chemical input is low in all countries. Thus farm output in these five countries in SSA responds more strongly to labour and land than to chemical input use.

Table 3.14: Nested F test for joint significance of cross-input elasticities

| Dependent Variable: | With no Controls | | Exclude Control for Capital | | Include Control for Capital | |
|---|---|---|---|---|---|---|
| Log Output Value | F-statistic | p-value | F-statistic | p-value | F-statistic | p-value |
| Ethiopia | 12.73 | 0.00 | 18.78 | 0.00 | 18.14 | 0.00 |
| Ghana | 2.09 | 0.10 | 2.80 | 0.04 | 2.39 | 0.07 |
| Malawi | 7.91 | 0.00 | 5.65 | 0.00 | 4.58 | 0.00 |
| Nigeria | 10.13 | 0.00 | 5.24 | 0.00 | 5.09 | 0.00 |
| Tanzania | 0.71 | 0.55 | 0.50 | 0.68 | 1.08 | 0.36 |

Note: All regressions in include controls for geo-climatic conditions, credit constraint (land value), farm (irrigation, farm-tool type, tractor use, crop type), land (ecological zones, soil quality, land ownership, land topology); and household characteristics (age, sex, marital status and education of household head). Robust standard errors clustered at the household level are in parentheses. The null hypothesis tested is $\beta_{LT} = \beta_{LM} = \beta_{TM} = 0$. Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

A further comparison reveals considerable differences in input elasticity estimates across countries, particularly, for labour and land. For example, the unconstrained estimate of the output elasticity of labour is 0.17 in Nigeria compared to 0.38 in Ethiopia, and for land it is 0.45 in Ghana compared to 0.30 in Nigeria. The joint explanatory power of the independent variables is satisfactory. In Ethiopia, the adjusted $\bar{R}^2$ is about 60%, and in Ghana, Nigeria, and Tanzania, the explanatory variables jointly explains about 40% of the variations in farm output. These results are fairly consistent with an alternative specification that altogether exclude land value.

However, the OLS technique estimates an average elasticity for the sample. Therefore, to have an estimate of input elasticities across the entire distribution of output, the study estimate a quantile regression (QR) for four distinct quantiles based on the market value of farm

Table 3.15: Cobb-Douglas estimation of the production function for all farms

| Dependent Variable: | Ethiopia | | Ghana | | Malawi | | Nigeria | | Tanzania | |
|---|---|---|---|---|---|---|---|---|---|---|
| Log Output Value | ( 1 ) | ( 2 ) | ( 1 ) | ( 2 ) | ( 1 ) | ( 2 ) | ( 1 ) | ( 2 ) | ( 1 ) | ( 2 ) |
| Labour | 0.38 *** | 0.42 *** | 0.23 *** | 0.29 *** | 0.21 *** | 0.33 *** | 0.17 *** | 0.33 *** | 0.36 *** | 0.49 *** |
| | ( 0.01 ) | ( 0.01 ) | ( 0.02 ) | ( 0.02 ) | ( 0.02 ) | ( 0.02 ) | ( 0.02 ) | ( 0.01 ) | ( 0.02 ) | ( 0.02 ) |
| Land | 0.34 *** | 0.34 *** | 0.45 *** | 0.56 *** | 0.41 *** | 0.50 *** | 0.30 *** | 0.51 *** | 0.33 *** | 0.41 *** |
| | ( 0.01 ) | ( 0.01 ) | ( 0.02 ) | ( 0.02 ) | ( 0.02 ) | ( 0.02 ) | ( 0.02 ) | ( 0.01 ) | ( 0.02 ) | ( 0.02 ) |
| Chemicals | 0.16 *** | 0.24 *** | 0.11 *** | 0.15 *** | 0.15 *** | 0.17 *** | 0.09 *** | 0.17 *** | 0.07 *** | 0.11 *** |
| | ( 0.01 ) | ( 0.01 ) | ( 0.01 ) | ( 0.01 ) | ( 0.01 ) | ( 0.01 ) | ( 0.01 ) | ( 0.01 ) | ( 0.01 ) | ( 0.01 ) |
| N | 17,987 | 17,987 | 4,675 | 4,675 | 5,236 | 5,236 | 4,580 | 4,580 | 5,214 | 5,214 |
| $\bar{R}^2$ | 0.55 | - | 0.43 | - | 0.32 | - | 0.35 | - | 0.43 | - |
| RMSE | 1.09 | 1.10 | 1.04 | 1.05 | 1.12 | 1.13 | 1.10 | 1.15 | 1.05 | 1.07 |

Note: All regressions in include controls for geo-climatic conditions, credit constraint (land value), farm (irrigation, farm-tool type, tractor use, crop type), land (ecological zones, soil quality, land ownership, land topology); and household characteristics (age, sex, marital status and education of household head). Robust standard errors clustered at the household level are in parentheses. Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
1 Denotes unconstrained model.
2 Denotes constrained model.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

Table 3.16: Quantile estimation of a Cobb-Douglas production function for all farms

| | Ethiopia | | | Ghana | | | Malawi | | | Nigeria | | | Tanzania | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dependent Variable: | Quantile | | | Quantile | | | Quantile | | | Quantile | | | Quantile | | |
| Log Output | 20th | 80th | Diff | 20th | 80th | Diff | 20th | 80th | Diff | 20th | 80th | Diff | 20th | 80th | Diff |
| Labour | 0.41 *** | 0.34 *** | -0.07 *** | 0.20 *** | 0.22 *** | 0.01 | 0.23 *** | 0.14 *** | -0.08 *** | 0.15 *** | 0.18 *** | 0.02 | 0.37 *** | 0.34 *** | -0.04 |
| | ( 0.01 ) | ( 0.01 ) | ( 0.02 ) | ( 0.02 ) | ( 0.02 ) | ( 0.04 ) | ( 0.03 ) | ( 0.03 ) | ( 0.03 ) | ( 0.02 ) | ( 0.02 ) | ( 0.03 ) | ( 0.02 ) | ( 0.02 ) | ( 0.03 ) |
| Land | 0.38 *** | 0.34 *** | -0.03 ** | 0.44 *** | 0.50 *** | 0.06 | 0.37 *** | 0.46 *** | 0.09 *** | 0.30 *** | 0.28 *** | -0.02 | 0.29 *** | 0.37 *** | 0.08 *** |
| | ( 0.01 ) | ( 0.01 ) | ( 0.02 ) | ( 0.03 ) | ( 0.03 ) | ( 0.04 ) | ( 0.02 ) | ( 0.03 ) | ( 0.03 ) | ( 0.03 ) | ( 0.02 ) | ( 0.02 ) | ( 0.02 ) | ( 0.02 ) | ( 0.03 ) |
| Chemicals | 0.18 *** | 0.12 *** | -0.06 *** | 0.11 *** | 0.11 *** | -0.01 | 0.16 *** | 0.13 *** | -0.03 | 0.09 *** | 0.09 *** | -0.01 | 0.06 *** | 0.08 *** | 0.01 |
| | ( 0.01 ) | ( 0.01 ) | ( 0.01 ) | ( 0.01 ) | ( 0.01 ) | ( 0.01 ) | ( 0.02 ) | ( 0.01 ) | ( 0.02 ) | ( 0.01 ) | ( 0.01 ) | ( 0.01 ) | ( 0.01 ) | ( 0.01 ) | ( 0.01 ) |
| N | 17,987 | 17,987 | - | 4,675 | 4,675 | - | 5,236 | 5,236 | - | 4,580 | 4,580 | - | 5,214 | 5,214 | - |
| Pseudo $R^2$ | 0.38 | 0.32 | - | 0.25 | 0.28 | - | 0.17 | 0.22 | - | 0.23 | 0.18 | - | 0.23 | 0.29 | - |

Note: All regressions in include controls for geo-climatic conditions, credit constraint (land value), farm (irrigation, farm-tool type, tractor use, crop type), land (ecological zones, soil quality, land ownership, land topology); and household characteristics (age, sex, marital status and education of household head). Robust standard errors clustered at the household level are in parentheses. Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

output: the 20th, 40th, 60th and the 80th quantiles. Table 3.16 presents the result of the analysis for the 20th and 80th quantiles. The table also reports the test of differences in elasticity estimates across the two

Table 3.17: Cobb-Douglas estimation of the production function for farm types

Panel A. Elasticity of inputs across subsistence and commercial farms

| Dependent Variable: | Ethiopia | | Ghana | | Malawi | | Nigeria | | Tanzania | |
|---|---|---|---|---|---|---|---|---|---|---|
| Log Output Value | Subs. | Comm. | Subs. | Comm. | Subs. | Comm. | Subs. | Comm. | Subs. | Comm. |
| Labour | 0.38 *** | 0.37 *** | 0.23 *** | 0.22 *** | 0.18 *** | 0.27 *** | 0.16 *** | 0.13 *** | 0.29 *** | 0.36 *** |
| | ( 0.01 ) | ( 0.03 ) | ( 0.03 ) | ( 0.02 ) | ( 0.03 ) | ( 0.04 ) | ( 0.02 ) | ( 0.02 ) | ( 0.02 ) | ( 0.03 ) |
| Land | 0.32 *** | 0.40 *** | 0.39 *** | 0.41 *** | 0.39 *** | 0.44 *** | 0.22 *** | 0.31 *** | 0.27 *** | 0.27 *** |
| | ( 0.01 ) | ( 0.03 ) | ( 0.03 ) | ( 0.03 ) | ( 0.03 ) | ( 0.04 ) | ( 0.02 ) | ( 0.03 ) | ( 0.02 ) | ( 0.02 ) |
| Chemical | 0.16 *** | 0.12 *** | 0.08 *** | 0.12 *** | 0.15 *** | 0.15 *** | 0.06 *** | 0.10 *** | 0.05 *** | 0.07 *** |
| | ( 0.01 ) | ( 0.02 ) | ( 0.02 ) | ( 0.01 ) | ( 0.01 ) | ( 0.02 ) | ( 0.01 ) | ( 0.01 ) | ( 0.01 ) | ( 0.01 ) |
| N | 15,937 | 2,050 | 1,583 | 3,092 | 3,528 | 1,708 | 2,584 | 1,996 | 3,097 | 2,117 |
| $\bar{R}^2$ | 0.54 | 0.52 | 0.38 | 0.38 | 0.34 | 0.34 | 0.37 | 0.38 | 0.35 | 0.48 |
| RMSE | 1.10 | 0.98 | 0.94 | 1.02 | 1.10 | 1.11 | 1.09 | 1.03 | 1.02 | 0.93 |

quantiles. Similar to the OLS results, the input elasticities are positive and statistically significant at the 1% significance level. Also, except for Ethiopia and Malawi, the elasticity estimates are consistent across the different quantiles. In Ghana and Nigeria, for example, the analysis shows no statistically significant differences in elasticity estimates for all inputs across the 20th and 80th quantiles, and in Tanzania, only for land. In Malawi, there are significant differences in elasticity estimate for labour and land, and in Ethiopia, statistically significant for all inputs.

Turning to the production function estimates for subsistence and commercial farms, Table 3.17 Panel A presents the unconstrained estimates of the output elasticity of inputs separately for each farm type. The estimates for all inputs $L$, $T$, $M$, are positive and statistically significant at the 1% significance level. The analysis also indicates considerable heterogeneity in the input elasticity estimates across the farm types. However, are these differences statistically significant? Are the

Panel B. Differences in input elasticities between subsistence and commercial farms

| | Subsistence Relative to Commercial | | | | |
|---|---|---|---|---|---|
| Elasticity Estimates | Ethiopia | Ghana | Malawi | Nigeria | Tanzania |
| Labour × Commercial Indicator | -0.01 | -0.04 | 0.09 * | -0.03 | 0.06 |
| | ( 0.03 ) | ( 0.04 ) | ( 0.05 ) | ( 0.03 ) | ( 0.03 ) |
| Land × Commercial Indicator | 0.09 *** | 0.01 | 0.07 | 0.03 | 0.04 |
| | ( 0.03 ) | ( 0.04 ) | ( 0.05 ) | ( 0.03 ) | ( 0.03 ) |
| Chemicals × Commercial Indicator | -0.02 | 0.02 | 0.02 | -0.01 | 0.03 ** |
| | ( 0.02 ) | ( 0.02 ) | ( 0.02 ) | ( 0.02 ) | ( 0.01 ) |
| Commercial Indicator | 0.56 *** | 0.76 *** | -0.17 | 0.70 *** | 0.51 *** |
| | ( 0.14 ) | ( 0.16 ) | ( 0.21 ) | ( 0.16 ) | ( 0.15 ) |
| N | 17,987 | 4,675 | 5,236 | 4,580 | 5,214 |
| $\bar{R}^2$ | 0.55 | 0.47 | 0.33 | 0.38 | 0.49 |
| RMSE | 1.09 | 1.00 | 1.12 | 1.08 | 0.99 |

Note: All regressions in include controls for geo-climatic conditions, credit constraint (land value), farm (irrigation, farm-tool type, tractor use, crop type), land (ecological zones, soil quality, land ownership, land topology); and household characteristics (age, sex, marital status and education of household head). Robust standard errors clustered at the household level are in parentheses. Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

differences in inputs use (see in Table 3.11) indicative of differences in farming techniques across the farm types? In order to address these questions, the study tests the significance of the estimated differences in input elasticities across subsistence and commercial farms by interacting the inputs with a binary indicator for farm commercialization. The indicator takes a value zero if the farm is classified as subsistence and one if the farm is commercial. Table 3.17 Panel B presents the result of the analysis. The analysis shows that except in few cases, most of the observed differences in input elasticities across the farm types are not statistically significant to induce differences in production technology across subsistence and commercial farms. This result is thus indicative

Table 3.18: Returns to scale in production

| Dependent Variable: | Exclude Control for Capital | | | With Control for Capital | | |
|---|---|---|---|---|---|---|
| Value of Output | All Farms | Subsistence | Commercial | All Farms | Subsistence | Commercial |
| Ethiopia | 0.88 *** | 0.87 *** | 0.92 *** | 0.87 *** | 0.86 *** | 0.90 *** |
| | ( 0.01 ) | ( 0.01 ) | ( 0.03 ) | ( 0.01 ) | ( 0.01 ) | ( 0.03 ) |
| Ghana | 0.85 *** | 0.76 *** | 0.80 *** | 0.79 *** | 0.71 *** | 0.75 *** |
| | ( 0.03 ) | ( 0.04 ) | ( 0.03 ) | ( 0.03 ) | ( 0.04 ) | ( 0.03 ) |
| Malawi | 0.83 *** | 0.80 *** | 0.87 *** | 0.76 *** | 0.72 *** | 0.86 *** |
| | ( 0.03 ) | ( 0.03 ) | ( 0.05 ) | ( 0.03 ) | ( 0.03 ) | ( 0.05 ) |
| Nigeria | 0.56 *** | 0.45 *** | 0.54 *** | 0.56 *** | 0.45 *** | 0.54 *** |
| | ( 0.03 ) | ( 0.03 ) | ( 0.03 ) | ( 0.03 ) | ( 0.03 ) | ( 0.03 ) |
| Tanzania | 0.83 *** | 0.68 *** | 0.81 *** | 0.75 *** | 0.61 *** | 0.71 *** |
| | ( 0.02 ) | ( 0.02 ) | ( 0.02 ) | ( 0.02 ) | ( 0.02 ) | ( 0.03 ) |

Note: All regressions in include controls for geo-climatic conditions, credit constraint (land value), farm (irrigation, farm-tool type, tractor use, crop type), land (ecological zones, soil quality, land ownership, land topology); and household characteristics (age, sex, marital status and education of household head). Robust standard errors clustered at the household level are in parentheses. Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
The return to scale measure is determined by adding together the coefficients/parameters on the variables $L$, $T$, and $M$ and testing if $\sum \beta_i = 1$.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

that while subsistence and commercial farms are characterized by similar production technology, they differ in the techniques they use along the same production possibility frontier. The result is also suggestive that pooled data at the country-level is appropriate.

To further characterize the production technology of farms, the study tests for returns to scale in production. The return to scale measure is determined by adding together the coefficients/estimates on labour, land, and chemical input in the production function estimation. A measure exceeding unity is indicative of an increasing returns to scale, and less than unity is suggestive of a decreasing returns to scale. A special case is when the measure is one, and the production technology

Table 3.19: Differences in TFP across farm types (cross-country analysis)

| | With Land Value | | | | | | | | | | | | Exclude Land Value | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Commercialization Rates | | | | | | | | | | No Farmer Controls | | Farmer Controls | | No Farmer Controls | |
| | 0% | | ≤ 20% | | ≤ 40% | | ≤ 60% | | < 100% | | 0% | | 0% | | 0% | |
| TFP | TFP Diff | (%) | TFP Diff | (%) | TFP Diff | (%) | TFP Diff | (%) | TFP Diff | (%) | TFP Diff | (%) | TFP Diff | (%) | TFP Diff | (%) |
| Regional Average | 0.42 *** | 8.6 | 0.28 *** | 5.6 | 0.23 *** | 4.6 | 0.19 *** | 3.8 | 0.02 | 0.5 | 0.43 *** | 9.3 | 0.40 *** | 7.7 | 0.41 *** | 8.1 |
| | ( 0.02 ) | | ( 0.02 ) | | ( 0.02 ) | | ( 0.02 ) | | ( 0.03 ) | | ( 0.02 ) | | ( 0.02 ) | | ( 0.02 ) | |

Note: All regressions in include controls for geo-climatic conditions, credit constraint (land value), farm (irrigation, farm-tool type, tractor use, crop type), land (ecological zones, soil quality, land ownership, land topology); and household characteristics (age, sex, marital status and education of household head). Robust standard errors clustered at the household level are in parentheses. Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.

Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

exhibits constant returns to scale. Table 3.18 reports the result of the analysis. The test rejects a CRS production technology in all farms at the 1% significance level. In all cases, the returns to scale measure is less than unity, and this indicates that the production technology of farms exhibits decreasing returns to scale.

### 3.5.2 TFP Differences across Farm Types

Next, the study examines farm-level TFP and the relationship between TFP and farm characteristics. In particular, I estimate TFP differences across farm types and test whether TFP is higher for commercial farms than subsistence farms in SSA.

#### Evidence from Cross-Country (Pooled) Analysis

Table 3.19 presents the result of the baseline regression analysis (i.e. for 0% commercialization rate) for the pooled cross-country data and for the Cobb-Douglas specification. This analysis pools together data on all countries and estimates an average TFP difference across commercial and subsistence farms for the region. On average, the analysis shows that TFP is about 10% higher for commercial farms than subsistence farms, and the difference is statistically significant at the 1% level. Table 3.19 presents additional robustness analyses based on alternative farm classifications and model specifications. The alternative farm classifications are based on commercialization cut-off rates (thresholds) of 20%, 40%, 60%, and 100%. For example, a commercialization threshold of 20% would classify all farms with commercialization rate of 20% or less as subsistence farms and more than 20% as commercial. These thresholds thus allow for near-subsistence considerations. At the extreme, a threshold of 100% strictly classifies commercial farms as farms that sell 100% of their farm output. Any farm selling less than 100% of its total output is classified as subsistence. Under alternative model specifications, the study estimates TFP differences across farm types by excluding controls for household characteristics, land value, or both household characteristics and land value.

Overall, the evidence shows no marked difference in TFP across subsistence and commercial farms, and that TFP is, on average, no more than 10% higher for commercial farms than for subsistence farms.

Table 3.20: Differences in TFP between subsistence and commercial farms

| | Cobb Douglas Specification | | | | | | | | Translog Specification | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No Controls | | | | With Controls | | | | No Controls | | | | With Controls | | | |
| | Unconstrained | | Constrained | | Unconstrained | | Constrained | | Unconstrained | | Constrained | | Unconstrained | | Constrained | |
| Countries | TFP Diff | (%) | TFP Diff | (%) | TFP Diff | (%) | TFP Diff | (%) | TFP Diff | (%) | TFP Diff | (%) | TFP Diff | (%) | TFP Diff | (%) |
| Ethiopia | 0.23 *** | 3.7 | 0.13 *** | 2.1 | 0.31 *** | 4.4 | 0.27 *** | 3.9 | 0.18 *** | 3.1 | 0.10 | 1.6 | 0.27 *** | 4.1 | 0.25 *** | 3.5 |
| | ( 0.03 ) | | ( 0.03 ) | | ( 0.03 ) | | ( 0.03 ) | | ( 0.03 ) | | ( 0.03 ) | | ( 0.03 ) | | ( 0.03 ) | |
| Ghana | 0.94 *** | 22.6 | 0.90 *** | 22.9 | 0.64 *** | 15.2 | 0.58 *** | 13.1 | 0.95 *** | 25.7 | 0.92 *** | 23.9 | 0.64 *** | 17.4 | 0.59 *** | 14.6 |
| | ( 0.04 ) | | ( 0.04 ) | | ( 0.04 ) | | ( 0.04 ) | | ( 0.04 ) | | ( 0.04 ) | | ( 0.04 ) | | ( 0.04 ) | |
| Malawi | 0.13 | 1.3 | 0.10 | 1.0 | 0.09 | 1.1 | 0.04 | 0.5 | 0.14 | 1.4 | 0.12 | 1.0 | 0.09 | 1.1 | 0.05 | 0.5 |
| | ( 0.03 ) | | ( 0.03 ) | | ( 0.04 ) | | ( 0.04 ) | | ( 0.03 ) | | ( 0.03 ) | | ( 0.04 ) | | ( 0.04 ) | |
| Nigeria | 0.45 *** | 4.5 | 0.37 *** | 4.0 | 0.49 *** | 4.6 | 0.34 *** | 3.3 | 0.44 *** | 4.5 | 0.37 *** | 3.8 | 0.49 *** | 4.6 | 0.35 *** | 3.1 |
| | ( 0.04 ) | | ( 0.04 ) | | ( 0.04 ) | | ( 0.04 ) | | ( 0.04 ) | | ( 0.04 ) | | ( 0.04 ) | | ( 0.04 ) | |
| Tanzania | 0.78 *** | 7.6 | 0.68 *** | 7.0 | 0.76 *** | 8.6 | 0.62 *** | 6.4 | 0.77 *** | 7.9 | 0.70 *** | 7.0 | 0.75 *** | 9.0 | 0.65 *** | 6.8 |
| | ( 0.03 ) | | ( 0.03 ) | | ( 0.03 ) | | ( 0.03 ) | | ( 0.03 ) | | ( 0.03 ) | | ( 0.03 ) | | ( 0.03 ) | |

Note: All regressions in include controls for geo-climatic conditions, credit constraint (land value), farm (irrigation, farm-tool type, tractor use, crop type), land (ecological zones, soil quality, land ownership, land topology); and household characteristics (age, sex, marital status and education of household head). Robust standard errors clustered at the household level are in parentheses. Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

## Evidence from Country-Level Analysis

Table 3.20 presents additional evidence for the baseline model based on country-level analysis, and for translog and Cobb-Douglas specifications. Except in Ghana, there are no substantial differences in TFP between subsistence and commercial farms irrespective of the estimation technique used and whether one explicitly controls for land, farm, or household characteristics. The estimates are consistent across both the translog and Cobb-Douglas specifications. Also, the null hypothesis of higher TFP for commercial farms relative to subsistence farms is rejected in Malawi; the evidence suggests that TFP is similar across subsistence and commercial farms. In Ethiopia and Nigeria, TFP is no more than 5% higher for commercial farms than subsistence farms,

Table 3.21: Differences in TFP estimates across farm types (robustness analysis)

| | Cobb Douglas Specification | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | With Land Value | | | | | | Land Value Excluded | |
| | Commercialization Rate | | | | | No Farmer Controls | Farmer Controls | No Farmer Controls |
| Country | 0% | ≤ 20% | ≤ 40% | ≤ 60% | < 100% | 0% | 0% | 0% |
| Ethiopia | 4.4 *** | 2.2 *** | 0.8 | 0.1 | -1.8 | 4.8 *** | 4.2 *** | 4.5 *** |
| Ghana | 15.2 *** | 11.4 *** | 8.6 *** | 7.1 *** | 4.5 *** | 17.7 *** | 15.0 *** | 16.4 *** |
| Malawi | 1.1 | -4.6 *** | -6.3 *** | -7.8 *** | -11.1 *** | 1.0 | 0.7 | 0.6 |
| Nigeria | 4.6 *** | 3.2 *** | 2.9 *** | 2.4 *** | -0.1 | 5.0 *** | 4.9 *** | 5.0 *** |
| Tanzania | 8.6 *** | 7.9 *** | 7.0 *** | 6.0 *** | 4.4 *** | 8.9 *** | 7.5 *** | 7.4 *** |

| | Translog Specification | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Control for Credit Constraint (Land Value) | | | | | | Exclude Land Value | |
| | Commercialization Rate | | | | | No Farmer Controls | Farmer Controls | No Farmer Controls |
| Country | 0% | ≤ 20% | ≤ 40% | ≤ 60% | < 100% | 0% | 0% | 0% |
| Ethiopia | 4.1 *** | 1.8 | 0.5 | -0.2 | -2.1 ** | 4.4 *** | 3.9 *** | 4.2 *** |
| Ghana | 17.4 *** | 13.1 *** | 9.8 *** | 8.1 *** | 5.1 *** | 20.7 *** | 17.4 *** | 19.0 *** |
| Malawi | 1.1 | -4.3 *** | -6.0 *** | -7.5 *** | -10.5 *** | 1.0 | 0.7 | 0.6 |
| Nigeria | 4.6 *** | 2.6 *** | 2.0 *** | 1.3 | -2.2 *** | 4.6 *** | 4.6 *** | 4.6 *** |
| Tanzania | 9.0 *** | 8.1 *** | 7.2 *** | 6.1 *** | 4.4 *** | 9.2 *** | 7.7 *** | 7.5 *** |

Note: All regressions in include controls for geo-climatic conditions, credit constraint (land value), farm (irrigation, farm-tool type, tractor use, crop type), land (ecological zones, soil quality, land ownership, land topology); and household characteristics (age, sex, marital status and education of household head). Robust standard errors clustered at the household level are in parentheses. Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

and in Tanzania, about 10% higher for commercial farms. Ghana is the only country where the TFP estimate is substantially higher for commercial farms than subsistence farms. Without any controls, TFP is about 20% higher for commercial farms than subsistence farms, and after controlling for farm, land, and household characteristics, it is about 15% higher.

Table 3.21 presents additional robustness analyses based on different commercialization thresholds and types of controls. The analyses show that the TFP estimates are fairly robust and consistent across alternative farm classifications or model specifications. There are no substantial differences in TFP across the subsistence and commercial farm types in most countries. Again, the hypothesis of higher TFP in commercial farms relative to subsistence farms is rejected in Malawi. In Ethiopia, Nigeria, and Tanzania, TFP is no more than 10% higher for commercial farms than subsistence farms, and in Ghana, the difference ranges from about 5% to 20% based on both the Cobb-Douglas and translog specifications. There, however, appears to be an inverse relationship between the degree of commercialization and TFP differences across the farm types. On average, the differences in TFP across the farm types tend to decline with higher level of farm commercialization. This thus suggests a greater potential for productivity gains through commercialization for the purely subsistence farms, especially, in Ghana and Tanzania.

It must, however, be noted that the use of a given commercialization rate is without any limitations. One of such limitations is the case where a critical mass of commercialization across the farming landscapes has not been reached and as a result, there is limited knowledge spillover between commercial farmers. This could suppress the productivity of commercial farms below their potential and thus further discourages greater entry into commercial farming. The data, for instance, shows marked differences in commercial rates across regions (see Table 3.22). In Ethiopia, for instance, the average commercialization rate is 10% for the Tigray region compared to only 2% for the Dire Dawa region.

In Ghana, the average commercialization rate is 68% for the Western region and 6% for the Upper West region and in Nigeria, it is 74% for the South West and 12% for the North East. In order to address these potential shortcomings, the study conducts further robustness analysis by examining productivity differences across subsistence and commercial farms in regions with high and low commercialization rates. Table 3.22 presents the results of the analyses. Except in Ghana and Tanzania, the analysis shows no marked differences in productivity across the subsistence and commercial farm types in regions with high and low commercialization rates. In Ghana, for example, the study finds that TFP is about 13.6% higher in commercial farms than subsistence farms in the low commercialization region and 22% higher for commercial farms than subsistence farms in the high commercialization region. These compare to the baseline TFP difference estimate of 15.2% reported in Table 3.20. In Tanzania, TFP is about 10.3% higher for commercial farms than subsistence farms in the region with the lowest commercialization rate and 10.2% higher for commercial farms than subsistence farms in the region with the highest commercialization rate. These compare to the baseline TFP difference estimate of 8.6%.

The preceding analyses were based on the assumption that the commercialization decision by a farmer is exogenous. However, this choice variable may be correlated with fixed inputs (land and soil quality), variable inputs (labour and chemicals), quasi-fixed inputs (such as farm

Table 3.22: Differences in TFP across subsistence and commercial farms in regions with low and high commercialization rates

| | Regions with Low Commercial Rates | | | | Regions with High Commercial Rates | | | |
|---|---|---|---|---|---|---|---|---|
| Country | Ave. Comm. Rate | TFP Diff. | S.E. | % TFP Diff. | Ave. Comm. Rate | TFP Diff. | S.E. | % TFP Diff. |
| Ethiopia | 0.02 | 0.32 * | 0.19 | 6.1 | 0.10 | 0.44 *** | 0.07 | 5.9 |
| Ghana | 0.06 | 0.43 *** | 0.15 | 13.6 | 0.68 | 0.90 *** | 0.21 | 22.0 |
| Malawi | 0.14 | -0.05 | 0.09 | -0.5 | 0.21 | 0.10 | 0.07 | 1.3 |
| Nigeria | 0.12 | 0.22 *** | 0.07 | 2.3 | 0.74 | 0.70 *** | 0.24 | 5.4 |
| Tanzania | 0.23 | 0.90 *** | 0.06 | 10.3 | 0.28 | 0.87 *** | 0.08 | 10.2 |

Note: All regressions in include controls for geo-climatic conditions, credit constraint (land value), farm (irrigation, farm-tool type, tractor use, crop type), land (ecological zones, soil quality, land ownership, land topology); and household characteristics (age, sex, marital status and education of household head). Robust standard errors clustered at the household level. Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

Table 3.23: Differences in TFP across subsistence and commercial farms using instrumental variable approach

| | Commercial Rate | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0% | | ≤ 20% | | ≤ 40% | | ≤ 60% | | < 100% | |
| Country | TFP Diff. | % TFP Diff. | TFP Diff. | % TFP Diff. | TFP Diff. | % TFP Diff. | TFP Diff. | % TFP Diff. | TFP Diff. | % TFP Diff. |
| Nigeria | 0.37 *** | 3.9 | 0.17 *** | 1.8 | 0.12 ** | 1.3 | 0.09 | 1.0 | -0.20 * | -2.0 |
| | ( 0.05 ) | | ( 0.06 ) | | ( 0.05 ) | | ( 0.07 ) | | ( 0.12 ) | |
| Tanzania | 0.65 *** | 8.1 | 0.58 *** | 7.2 | 0.50 *** | 6.1 | 0.40 *** | 4.9 | 0.24 *** | 2.9 |
| | ( 0.05 ) | | ( 0.05 ) | | ( 0.06 ) | | ( 0.06 ) | | ( 0.07 ) | |

Instrumented: current period's labour and chemical inputs use. Instruments include previous year's labour and chemical inputs use while controlling for geo-climatic conditions, credit constraint (land value), farm (irrigation, farm-tool type, tractor use, crop type), land (ecological zones, soil quality, land ownership, land topology); and household characteristics (age, sex, marital status and education of household head). Reports robust standard errors clustered at the household level in parentheses. Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Nigeria (2012/13) and Tanzania (2012/13).

tool type and tractor use). The presence of these endogenous regressors could produce inconsistent parameter estimates and thus affect the estimates of the productivity differences across farm types. However, while unobservable characteristics could be important in accounting for productivity differences across farm types (see section 3.5.2), this study controls for this problem by using self-reported measures of land/plot quality by farmers. Also, both farm types use similar farm tools (cutlasses and hoes) and there is minimal use of tractors and other mechanized farm tools. In any case, to address potential concerns for endogeneity, the study adopts the instrumental variable (IV) technique and re-estimates the model using previous year's inputs use as instruments for the current period's inputs use whenever they are available (only for Nigeria and Tanzania). Table 3.23 presents the estimates using IV and for different commercialization rates. In Nigeria, the analysis shows no statistically significant differences in TFP between the subsistence and commercial farm type. In Tanzania, the study estimate that TFP is at most about 10% higher for commercial farms than subsistence farms; fairly consistent with the baseline OLS estimates. Also, similar to the OLS estimates, the percentage differences in TFP across the farm types decline as one tighten the definition of commercialization and restrict commercial farms to only farms with higher commercialization rates. Table 3.24 further presents tests of validity for the instruments. The null hypothesis of exogeneity of the instrumented variables is rejected for both countries and for the different commercialization rates. The null hypothesis of under-identification is also rejected thus suggesting that model is identified and the excluded instruments are "relevant" and correlated with the endogenous regressors. The tests further reject the notion of weak identification of the instruments. The Kleibergen-Paap Wald F statistics are statistically significant; the test statistics

Table 3.24: Tests of endogeneity, under-identification, and weak identification

| | Nigeria | | | | | Tanzania | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0% | $\leq$ 20% | $\leq$ 40% | $\leq$ 60% | < 100% | 0% | $\leq$ 20% | $\leq$ 40% | $\leq$ 60% | < 100% |
| Endogeneity (Robust F Statistics) | 5.23 | 5.77 | 5.74 | 5.76 | 5.77 | 3.88 | 4.12 | 3.90 | 4.63 | 4.53 |
| | (0.01) | (0.00) | (0.00) | ( 0.00) | (0.00) | (0.02) | (0.02) | (0.02) | (0.01) | ( 0.01) |
| Underidentification (KP LM statistic) | 22.67 | 22.44 | 22.19 | 23.364 | 22.73 | 127.92 | 128.57 | 128.47 | 128.752 | 129.56 |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | ( 0.00) | (0.00) | (0.00) |
| Weak Identification (KP Wald F statistic) | 12.09 | 11.99 | 11.82 | 12.47 | 12.13 | 79.14 | 79.78 | 79.77 | 79.92 | 80.33 |

P values are in parentheses

exceed the reported Stock-Yogo weak identification test critical values.

In sum, while many countries in SSA have made commercialization of agriculture a policy priority to raise productivity in agriculture, the preceding analysis estimates TFP across subsistence and commercial farms and test if TFP is higher for commercial farms than subsistence farms. The evidence presented in this section shows no substantial differences in TFP across the broad farm types. Except in Ghana and Tanzania, TFP is similar across subsistence and commercial farms. In Ghana, TFP is about 15% higher for commercial farms than subsistence farms and in Tanzania, about 10% higher for commercial farms than subsistence farms. The results are also robust across alternative farm classifications and model specifications, and also consistent with the literature. Abate et al. (2018), for example, find that adoption of the complete wheat technology package in Ethiopia increases yield by only 14% at harvest. Thirtle et al. (1993b) estimate a higher TFP growth for communal farms in Zimbabwe than commercial farms.

### Understanding Differences in TFP across Farm Types

In order to have a better understanding of TFP differences across farm types and its drivers, the study further ascertains if the observed differences in TFP are driven by geo-climatic, land (soil quality), farm, and household characteristics. Table 3.25 presents the ratio of the means on geo-climatic conditions (temperature, total precipitation, rainfall), soil quality (terrain roughness, soil wetness, nutrient availability and retention, rooting conditions, oxygen availability, excess salt, toxicity, workability condition), plot/farm characteristics (irrigation, crop stand, crop type, agro-ecological zone), and household characteristics (age, sex, education, marital status) for subsistence farms relative to commercial farms.

In Ethiopia, with the exception of total precipitation, geo-climatic conditions, soil, plots, and farmer characteristics are similar across subsistence and commercial farms. In particular, the majority of the farms are located in the plateau and mountainous regions with tropical-cool arid and humid conditions. As a result, land wetness, soil quality measures, and soil types (mostly vertisol and luvisol) are similar across subsistence and commercial farms. Also, about 4% of subsistence farms reported irrigation use. This compares to less than 2% for commercial farms, and in both farms, about 80% of the farms are pure stand cultivating mostly cereals and vegetables. Moreover, the average age and household heads reporting no formal education are respectively 47

Table 3.25: Comparison of land, farm, and farmer characteristics across farm types

| | Ethiopia | Ghana | Malawi | Nigeria | Tanzania |
|---|---|---|---|---|---|
| Category | Ratio | Ratio | Ratio | Ratio | Ratio |
| Temperature ($^0$Celcius) | 0.97 | | 1.01 | 1.00 | 1.00 |
| Annual precipitation (mm) | 1.03 | | 1.07 | 0.89 | 1.05 |
| Potential wetness scale (scale of 1-10) | 0.98 | | 0.99 | 1.01 | 0.98 |
| Terrain roughness (no constraint = 1; severe constraint = 3) | 1.06 | | 1.12 | 0.89 | 1.03 |
| Nutrient availability (no constraint = 1; severe constraint = 3) | 1.06 | | 0.98 | 1.10 | 1.05 |
| Nutrient retention capacity (no constraint = 1; severe constraint = 3) | 1.06 | | 1.01 | 1.09 | 1.06 |
| Rooting condition (no constraint = 1; severe constraint = 3) | 1.04 | | 1.09 | 0.98 | 1.04 |
| Oxygen availability (no constraint = 1; severe constraint = 3) | 0.96 | | 1.02 | 1.02 | 1.04 |
| Excess salt (no constraint = 1; severe constraint = 3) | 1.00 | | 1.07 | 1.02 | 1.04 |
| Toxicity (no constraint = 1; severe constraint = 3) | 1.00 | | 1.06 | 0.99 | 1.05 |
| Workability condition (no constraint = 1; severe constraint = 3) | 1.00 | | 1.14 | 0.98 | 1.06 |
| Agro-ecological zone (tropical warm = 1; tropical cold = 0) | 1.00 | 1.11 | 1.00 | 1.00 | 1.00 |
| Annual rainfall (mm) | 1.01 | 0.96 | 1.05 | 0.95 | 1.02 |
| Crop stand (multi-crop = 1; pure stand = 0) | 1.51 | 1.04 | 2.04 | 1.17 | 1.19 |
| Irrigation use (yes = 1; no = 0) | 1.70 | 0.35 | 1.05 | 0.56 | 0.31 |
| Crop type (tuber = 1; cereal = 2; vegetable = 3; fruit = 4; cash crop = 5) | 1.04 | 0.64 | 0.57 | 0.77 | 0.88 |
| Age of household head (years) | 1.02 | 1.03 | 1.06 | 0.99 | 1.08 |
| Gender of household head (male = 1; female = 0) | 0.96 | 1.03 | 0.87 | 1.00 | 0.91 |
| Marital status of household head (married = 1; single = 0) | 0.96 | 1.07 | 0.89 | 1.00 | 0.91 |
| Household head with formal education (yes = 1; no = 0) | 1.04 | 0.62 | 0.96 | 0.93 | 0.92 |
| Highest grade completed (primary = 1; secondary = 1; tertiary = 2) | 1.01 | 0.85 | 0.99 | 0.99 | 1.00 |

Note: The ratio is computed as the mean characteristic for subsistence farm relative to commercial farm.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

years and 65% for subsistence farms compared to 46 years and 65% respectively for the commercial farm type. Also, for both farm types, over 90% of the household heads reported having low education and completing mostly elementary or primary school.

In Ghana, about 80% of subsistence and commercial farms are located in the rural forest and Savannah zones. As such, rainfall and soil quality are similar across the farm types. Only 1% of subsistence farms report irrigation activities compared to 6% for commercial farms, and both pure and mixed farming/cropping are equally practised across farm types. However, whereas subsistence farms are mostly engaged in tubers and cereal production, 30% of commercial farms do specialize in horticulture and cash crops. Also, 70% of household heads for the subsistence farm type reported having no formal education compared to only 40% for commercial farms, and about 50% of the household heads for both farm types reported completing grade six or lower.

In Malawi, about 90% of subsistence and commercial farms are located in the tropical warm zone, with mostly plains and plateau landscapes. Consequently, annual precipitation/rainfall, soil wetness, and soil type and quality are similar across both farm types. Also, irrigation use is low in both farms (less than 1% report irrigation use), and 60% of the farms are pure stand producing mostly cereals and vegetables. Both farm types are dominated by male household heads and over 80% of the household heads reported having some form of formal education but mostly completing grade six or lower.

In Nigeria, annual precipitation is slightly higher for subsistence farms than for commercial farms. However, soil quality, as well as the potential wetness index and terrain roughness are similar across subsistence and commercial farms. About 90% of the farms are situated in the plains and low plateau regions with tropical-warm climatic conditions. Also, nutrient availability to plants, retention, and oxygen supply do not seem to pose severe constraints to both farm types. Irrigation use is minimal; only 2% of farms reported irrigation use. Also, 40% of the farms are pure stands and more than 60% are engaged in tubers and cereal production. Households are dominated by male heads and about 60% of heads reported having some form of formal education but mostly completing grade six.

In Tanzania, the majority of farms are located in the high-altitude plains and mid-altitude plateaus with tropical warm and cold climatic conditions. Hence, soil type and quality, as well as average precipitation and rainfall are similar across subsistence and commercial farms. Irrigation use is not widespread; only 2% of subsistence farms reported irrigation use compared to 5% for commercial farms. The majority of farms specialize in cereal and vegetable production, and about 50% of farms are pure stand. Also, over 80% of the farming households are dominated by male heads, and 70% reported having a formal education but completing mostly grade six or lower.

In sum, the evidence shows that, except in some few cases, there are no significant differences in geo-climatic, soil, farm/plot, and household characteristics across subsistence and commercial farms. This findings partly explain why we do not observe any significant differences in farm-level TFPs across the farm types in Ethiopia, Malawi, and Nigeria. In Ghana and Tanzania, while plot and household characteristics are similar across subsistence and commercial farms, there are substantial differences in irrigation use across farm types. However, in both countries, irrigation use is generally low thus suggesting a possible role for policy or some unobservable farmer/land (e.g. land tenure system) characteristics in accounting for the higher TFP in commercial farms than subsistence farms.

The agricultural policy in Ghana follows a market-driven logic and seeks to promote private sector engagement. The policy is producer-oriented and in particular, emphasizes agricultural modernization. In line with this objective, the government has implemented several policies including the reintroduction of the National fertilizer Subsidy (NFS) program in 2008, the launch and expansion of the Agriculture mechanization Services Enterprises Centres (AMSECs) program in 2007, the Block Farming program in 2009, and the National Irrigation Development program (FAO, 2015). The NFS program, for example, subsidizes fertilizer to all farmers engaged in crop production. The fertilizer is distributed in the form of fertilizer-specific and region-specific vouchers. The AMSECs program assists private investors to purchase agricultural machinery at a subsidized price and interest rate and who in turn rent them to rural farmers at affordable prices. There is also increasing effort on the part of the government to increase farmers access to agricultural finance (FAO, 2015). While open to all farm types, commercial farms are, nonetheless, more likely to take advantage of such programs than subsistence farms. Commercial farmers are market-driven and have a higher incentive to participate in machinery rental markets. They also have a higher incentive to lobby for a greater share of the agricultural finance and fertilizer vouchers.[12]

In Tanzania, the national agricultural policy places greater emphasis

[12] In 2011, the government through a public-private partnership, also introduced the Ghana Agricultural Insurance Programme (GAIP). This is the country's first agricultural insurance system to protect farmers against financial risks resulting from climate change. This policy is likely to further drive a wedge in productivity between the subsistence and commercial farm types. Commercial farms can now afford to take higher risk and invest in productivity-improving technologies.

on market economy reforms. The policy focuses on farm commercialization, competitiveness and an increased role for the private sector in agriculture (FAO, 2014). In 2008, the government also re-introduced the input subsidies program, but this has been abandoned. Agricultural credit was also given greater attention. However, since 2000 and throughout 2007–2013, the government intermittently imposed temporary export bans on staple crops such as cereals, which are the most stable crops cultivated by smallholder subsistence farms (FAO, 2014). While the National Inputs Voucher Scheme (NAIVS) provides maize and rice farms access to fertilizer and seeds through subsidized input packages, the periodic bans on cereal export could potentially discourage subsistence farmers from investing in productivity-enhancing technologies to raise farm production.

Moreover, in Ghana, public lands are vested in the President in trust for the people. However, all stool lands are vested in customary governments on behalf of and in trust for the subjects of the stool. About 80% of the country's land is held under the customary land tenure systems, and this system broadly discriminates against women (sar, ????). The customary land system generally ascribed men exclusive right to land while women are excluded. Most women either cultivate their husbands' fields or gain access to farmlands through the male members of the family (sar, ????). In Tanzania, the percentage of female agricultural holders is about 20% while the share of agricultural land area that is owned by women is only 16%. Also, only 15% women reported able to sell or use the land as collateral compared to 44% for men (Doss, Kovarik, Peterman, Quisumbing, and van den Bold, 2015).

These shreds of evidences point to significant disparities in land access and distribution of farmland across males and females, thus putting the large number of women (about 50%) who are mostly engaged in subsistence agriculture at a complete disadvantage.

### 3.5.3 Technical Efficiency across Farm Types

Next, this chapter also estimates technical efficiency (TE) across subsistence and commercial farms. Like TFP, TE is vital to the prospects of agriculture in SSA. Yet, its implications for farm-level and aggregate productivity are poorly understood. This section advances our knowledge in this respect by measuring technical efficiency across subsistence and commercial farms in SSA. Unlike TFP, TE directly measures the level of inefficiencies inherent in the production technology of farms and can also identify the sources of production inefficiencies. This exercise is thus, particularly important given the vital role small and subsistence farms play in combating poverty and enhancing food security in SSA. Also, if subsistence farms demonstrate production efficiency advantages, there could be a heterogeneous farm structure, in which subsistence and commercial farms coexist despite considerable differences in productivity across the broad farm types.

Generally, two broad approaches have been proposed to measure technical efficiency: the data envelop analysis (DEA) and stochastic frontier analysis (SFA). The DEA methodology uses mathematical programming to estimate the production frontier and technical efficiency. However, this approach (i) does not account for measurement error, (ii) is deterministic, and (iii) does not explicitly account for the diversity of shocks involved in crop production.[13] The stochastic production frontier models, developed by Aigner, Lovell, and Schmidt (1977) and Meeusen and van Den Broeck (1977), overcome these limitations and uses a distance function to measure technical inefficiency across farms. This study estimates TE using the stochastic frontier approach.

Given a well-defined production structure, a gross output function, and a vector of inputs, the production function of a farm can be expressed as $f(\mathbf{z}_i\beta)$. In the absence of technical inefficiency, the $i$th farm would produce:

$$Q_i = f(\mathbf{z}_i\beta),$$

where $Q_i$ is the output of the $i$th farm, $f$ is the production function, $\mathbf{z}$ is a vector of production inputs (including labour, land, and chemical inputs), and $\beta$ is the vector of parameters of the production function. The stochastic frontier analysis assumes that in the presence of technical inefficiency, a farm may produce less than its potential

$$Q_i = f(\mathbf{z}_i\beta)\zeta_i,$$

where $\zeta_i \in (0, 1]$ is the efficiency term for farm $i$. When the efficiency

[13] See for example Coelli (1995) and more recently, Kagin, Taylor, and Yúnez-Naude (2016).

parameter is one, the $i$th farm uses its inputs optimally, and produces on the production frontier. When $0 < \zeta_i < 1$, the $i$th farm produces below its potential and exhibits technical inefficiency. Farm output can also be subject to a random shock ($\upsilon$) which is assumed to be symmetric and $iid \sim N(0, \sigma_\upsilon^2)$. Hence, the stochastic production function can be written as

$$Q_i = f(\mathbf{z}_i\beta)\zeta_i \exp(\upsilon_i).$$

Taking the natural log of both sides yields

$$\ln Q_i = \ln f(\mathbf{z}_i\beta) + \ln(\zeta_i) + \upsilon_i. \quad (3.5)$$

Assuming $k$ inputs, log-linear Cobb-Douglas production function, and defining the technical inefficiency term $u_i = -ln(\zeta_i)$, where $u_i \geq 0$ and is independent of $\upsilon_i$, the stochastic production frontier is given as

$$\ln Q_i = \beta_0 + \sum_{j=1}^{k} \beta_j \ln(Z_{ji}) + \upsilon_i - u_i. \quad (3.6)$$

Equation (3.6) shows that the observed deviations of farm output from the efficient production frontier could arise from two sources: (i) technical inefficiency ($u_i$) and (ii) idiosyncratic stochastic effect specific to the farm ($\upsilon_i$).[14]

To identify all parameters in (3.6) and retrieve the TE parameter,

[14]Below I estimate technical efficiency using the general translog specification and equation (3.6) is modified accordingly.

the conventional approach assumes that: (i) $u_i$ is independently exponentially distributed with variance $\sigma_u^2$; (ii) $u_i$ is independently half-normally $N^+(0;\sigma_u^2)$ and; (iii) $u_i$ is independently $N^+(\mu;\sigma_u^2)$ distributed with truncation point at 0. This study follows the approach of Henderson (2015) and assumes the following about the distribution of $u_i$ and $\upsilon_i$: $\upsilon_i \sim N(0,\sigma_\upsilon^2)$ and $u_i \sim N^+(0;\sigma_{ui}^2)$. The variance component of $u_i$ is determined as

$$\sigma_{ui}^2 = \exp(X_i^{'}\gamma)$$

where $X^{'}$ corresponds to an $M \times 1$ vector of variables that determine technical inefficiency and these controls include land size and household demographic characteristics such as age, sex, and the educational level of household heads. Using equation (3.6), $u_i$ can be predicted by $E(u_i|\upsilon)$ and the technical efficiency term can be computed as $TE_i = \exp(-u_i)$.[15] The stochastic production frontier estimation is implemented in Stata using the "frontier" command and TE computed using the "predict" command.

Table 3.26 presents estimates of the technical efficiency term from equation (3.6). Overall, both the subsistence and commercial farm types exhibit substantial inefficiencies, and on average, produce about 50% below potential (i.e. relative to best practice farms). In Ethiopia and Nigeria, the technical efficiency estimate is similar across subsistence and commercial farms. In Ghana, Malawi, and Tanzania, "TE" is higher for commercial farms than for subsistence, suggesting that

[15]Higher value of $u_i$ implies lower efficiency or higher inefficiency.

Table 3.26: Estimates of technical inefficiency across subsistence and commercial farms

| Dependent Variable:<br>Log Market Value of Output | TFP Difference (%) | All Farms | Subsistence | | Commercial |
|---|---|---|---|---|---|
| Cross-Country (Pooled) | 8.61 | 0.52 | 0.52 | ≈ | 0.53 |
| Ethiopia | 4.44 | 0.55 | 0.56 | ≈ | 0.57 |
| Ghana | 15.20 | 0.55 | 0.53 | < | 0.75 |
| Malawi | 1.12 | 0.49 | 0.46 | < | 0.55 |
| Nigeria | 4.61 | 0.47 | 0.48 | ≈ | 0.51 |
| Tanzania | 8.65 | 0.49 | 0.50 | < | 0.56 |

Note: The reported value is $\zeta_i = \exp(-u_i)$, where $\zeta_i \in (0, 1]$ is a measure of technical efficiency
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

Table 3.27: Technical inefficiency

| Dependent Variable: | Ethiopia | | Ghana | | Malawi | | Nigeria | | Tanzania | |
|---|---|---|---|---|---|---|---|---|---|---|
| Technical inefficiency | Subs. | Comm. | Subs. | Comm. | Subs. | Comm. | Subs. | Comm. | Subs. | Comm. |
| Size of Plot | -0.16 *** | -0.13 * | 0.12 | 0.50 *** | 0.03 | -0.12 | -0.23 *** | -0.28 *** | 0.23 *** | 0.04 |
| | ( 0.02 ) | ( 0.08 ) | ( 0.09 ) | ( 0.13 ) | ( 0.05 ) | ( 0.13 ) | ( 0.05 ) | ( 0.07 ) | ( 0.05 ) | ( 0.07 ) |
| Age of Household Head | 0.23 | -0.48 | -0.20 | -0.07 | -0.02 | 0.61 * | 0.65 *** | 0.55 * | 0.03 | -0.85 *** |
| | ( 0.14 ) | ( 0.32 ) | ( 0.27 ) | ( 0.33 ) | ( 0.14 ) | ( 0.37 ) | ( 0.23 ) | ( 0.33 ) | ( 0.21 ) | ( 0.31 ) |
| Sex of Household Head | 0.01 | 1.11 ** | -0.69 *** | -0.24 | -0.04 | 0.98 * | -0.46 ** | 0.05 | -0.09 | 0.51 * |
| | ( 0.11 ) | ( 0.59 ) | ( 0.22 ) | ( 0.29 ) | ( 0.11 ) | ( 0.54 ) | ( 0.19 ) | ( 0.26 ) | ( 0.15 ) | ( 0.28 ) |
| Education of Household Head: | | | | | | | | | | |
| Ever Attended School | 0.13 | 0.05 | 0.85 *** | 0.11 | -0.12 | 0.10 | 0.49 *** | 0.15 | 0.09 | -0.54 *** |
| | ( 0.10 ) | ( 0.22 ) | ( 0.25 ) | ( 0.30 ) | ( 0.13 ) | ( 0.34 ) | ( 0.14 ) | ( 0.18 ) | ( 0.15 ) | ( 0.20 ) |
| Level Completed (Secondary) | 0.25 * | 0.08 | 0.12 | 0.25 | 0.03 | -0.50 | -0.29 | 0.08 | 0.40 ** | -0.76 |
| | ( 0.15 ) | ( 0.35 ) | ( 0.26 ) | ( 0.29 ) | ( 0.12 ) | ( 0.31 ) | ( 0.20 ) | ( 0.24 ) | ( 0.19 ) | ( 0.66 ) |
| Level Completed (Post-Secondary) | 0.88 *** | -5.28 | -0.89 | -0.06 | -0.43 *** | -0.12 | -0.01 | -0.23 | 0.09 | -2.19 |
| | ( 0.21 ) | ( 13.57 ) | ( 0.59 ) | ( 0.55 ) | ( 0.15 ) | ( 0.28 ) | ( 0.24 ) | ( 0.36 ) | ( 0.55 ) | ( 3.48 ) |

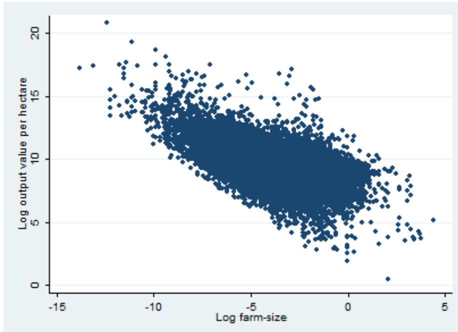
Note: Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

subsistence farms exhibit higher technical inefficiency than commercial farms. In Ghana, for example, commercial farms produce only 25% below potential compared to 50% for subsistence farms. Except for Malawi, the results are largely consistent with the differences in TFP estimation.

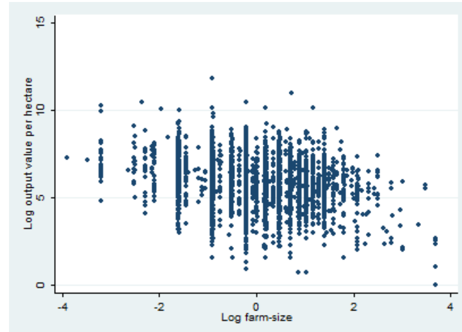
Table 3.27 further examines the source of technical inefficiency across the broad farm types. Two interesting conclusions emerge from the analysis. First, the result suggests that $TE$ is less likely driven by household demographic characteristic and more likely by farm characteristics such as plot sizes. In most cases, the estimated coefficient on age, sex, and education are not statistically different from zero. In Ghana and Tanzania, technical inefficiency increases with plot size, and in Ethiopia and Nigeria, it decreases with plot size. In Ethiopia and Nigeria, the average plot sizes are small, whereas, in Ghana and Tanzania, average plot sizes are relatively large. Differences in average plot sizes thus raise the possibility of plot management as a plausible explanation for the differences in technical inefficiency across countries.

Second, factors driving technical inefficiency are more likely country-specific. For example, in Ghana, technical inefficiency increases with plot size but decreases with age and sex of the household head. In Ethiopia, it decreases with plot size and increases with age and sex of the household head. In Nigeria, it decreases with plot size and sex and increases with the age of household head. Surprising, whether a household head has obtained formal education or completed secondary school does not matter for technical efficiency. In most cases, the coefficient on these variables is positive but not statistically significant. There is, however, some evidence of technical inefficiency decreasing with higher levels of education in Ghana, Malawi, and Nigeria. Nonetheless, except in Malawi, the coefficient on this variable is not statistically significant.

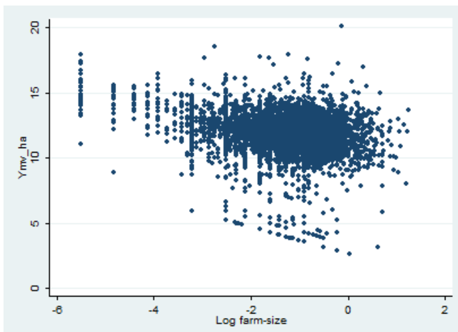
Figure 3.4: The relation between farm productivity and farm-size



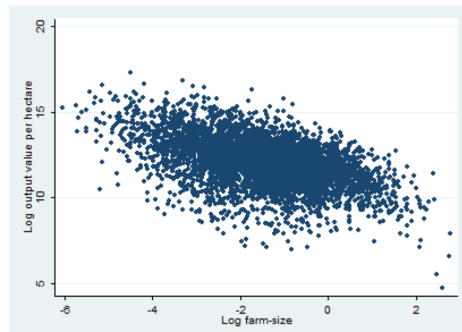

(a) Ethiopia



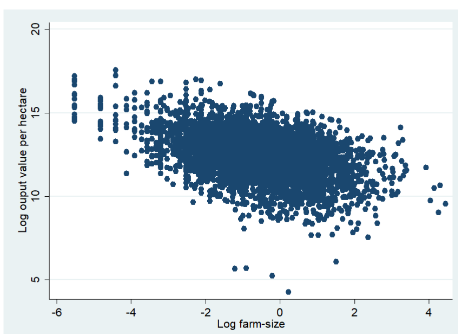

(b) Ghana




(c) Malawi




(d) Nigeria




(e) Tanzania

Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

### 3.5.4 Farm Productivity and Farm-size Nexus

With the farm-level data in hand, it is possible to revisit the size-productivity nexus, test the inverse relation (IR) hypothesis between farm-size and farm productivity, and also estimate TFP across small and large farms. Consistent with the empirical literature, the dependent variable in the IR equation is log market value of output per hectare and the independent variable is log plot/land size. A negative coefficient on land size is suggestive of an inverse relationship between farm size and farm productivity. I also control for other inputs use (such as labour and chemicals) and a set of factors that could potentially affect farm productivity. These include rainfall; land value (proxy for credit constraint); farm characteristics (irrigation, farm-tool type, hired tractor use, crop types); land characteristics (agro-ecological zones, soil quality, land ownership, land topology); and farmer/household characteristics (age, sex, marital status, education of household head). Figure 3.4 shows a scatter plot of the log of market value of output per hectare and log land/plot size (ha). The figure indicates an inverse relation between farm-size and land productivity in all countries, and particularly strong in Ethiopia, Nigeria, and Tanzania.

Table 3.28 presents additional evidences on the relation between farm-size and farm productivity. The analysis confirms the IR hypothesis in all countries. This thus suggests that small farms, on average, exhibit higher land productivity (i.e. output per hectare) than large farms. The inverse relation still persists even after controlling for additional inputs use, farm, land, and household demographic characteristics. There is, however, a significant drop in the point estimates for land size, decreasing by about 40% in Malawi and Tanzania and 70% in Ethiopia. Nonetheless, taken on its face value, this could imply that

Table 3.28: The relation between farm productivity and farm-size

| Dependent Variable: | Exclude Controls | | | | |
|---|---|---|---|---|---|
| Log Output per Hectare | Ethiopia | Ghana | Malawi | Nigeria | Tanzania |
| Log Land (Ha) | -0.45*** | -0.28*** | -0.38*** | -0.53*** | -0.43*** |
| | (0.01) | (0.03) | (0.02) | (0.02) | (0.01) |
| N | 20,232 | 4,711 | 6,035 | 4,948 | 5,236 |
| $\bar{R}^2$ | 0.35 | 0.04 | 0.08 | 0.25 | 0.19 |
| | Include Controls | | | | |
| Log Output per Hectare | Ethiopia | Ghana | Malawi | Nigeria | Tanzania |
| Log Land (Ha) | -0.13*** | -0.21*** | -0.24*** | -0.44*** | -0.25*** |
| | (0.01) | (0.03) | (0.03) | (0.03) | (0.02) |
| N | 17,987 | 4,675 | 5,236 | 4,580 | 5,214 |
| $\bar{R}^2$ | 0.49 | 0.10 | 0.23 | 0.37 | 0.35 |

Note: All regressions in include controls for geo-climatic conditions, credit constraint (land value), farm (irrigation, farm-tool type, tractor use, crop type), land (ecological zones, soil quality, land ownership, land topology); and household characteristics (age, sex, marital status and education of household head). Robust standard errors clustered at the household level are in parentheses. Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

the predominance of small farms in agriculture in SSA may not necessarily be the reason for the sector's low productivity. When a similar exercise (Appendix B.4 Table B.7) is conducted defining productivity in terms of output per labour rather than output per land, the study finds no evidence in support of the IR hypothesis.

Finally, Table 3.29 presents estimates of TFP differences across large and small farms, and test if TFP is higher for large farms than small farms. The analysis, however, shows no significant differences in TFP across small and large farms in Ethiopia, Malawi, Nigeria, and Tanzania. In Ethiopia, Nigeria, and Tanzania, TFP is similar across small and

Table 3.29: TFP estimate for large farms relative to small farms

| | No Controls | | With Controls | | | |
|---|---|---|---|---|---|---|
| | No Controls | | Exclude Land Value | | Include Land Value | |
| Country | TFP Difference | % Difference | TFP Difference | % Difference | TFP Difference | % Difference |
| Ethiopia | 0.53 *** | 8.6 | 0.16 | 2.2 | 0.08 | 1.1 |
| | ( 0.14 ) | | ( 0.14 ) | | ( 0.17 ) | |
| Ghana | 0.21 *** | 4.4 | 0.21 *** | 4.4 | 0.21 *** | 4.6 |
| | ( 0.06 ) | | ( 0.05 ) | | ( 0.05 ) | |
| Malawi | -0.33 | -3.3 | -0.33 | -3.5 | -0.36 | -4.4 |
| | ( 0.32 ) | | ( 0.29 ) | | ( 0.28 ) | |
| Nigeria | -0.20 | -1.9 | -0.06 | -0.5 | -0.06 | -0.5 |
| | ( 0.09 ) | | ( 0.09 ) | | ( 0.09 ) | |
| Tanzania | 0.05 | 0.5 | 0.07 | 0.6 | 0.02 | 0.2 |
| | ( 0.06 ) | | ( 0.06 ) | | ( 0.06 ) | |

Note: All regressions in include controls for geo-climatic conditions, credit constraint (land value), farm (irrigation, farm-tool type, tractor use, crop type), land (ecological zones, soil quality, land ownership, land topology); and household characteristics (age, sex, marital status and education of household head). Robust standard errors clustered at the household level are in parentheses. Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey years (in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13).

large farms, and in Malawi, higher for small farms than large farms. However, the differences in TFP estimates across the farm sizes are not statistically significant. In Ghana, the analysis shows that TFP is about 5% higher for large farms than small farms.

In summary, the analysis confirms the inverse relation hypothesis in all countries, thus suggesting that small farms are on average, more productive (higher output per hectare) than large farms. However, additional evidence based on TFP estimates show no substantial differences in TFP across the large and small farm holdings. The evidence thus suggests that TFP differences between subsistence and commercial farm types are more economically relevant for the transformation of agriculture in SSA than TFP differences between small and large farms.

### 3.5.5 Commercialization and Labour Reallocation in SSA

The preceding sections characterized the production technology of farms, and estimate TFP and TE across subsistence and commercial farms. in this section, I examine the implications of farm commercialization for labour reallocation across sectors. In particular, I quantify the potential labour reallocation associated with the commercialization of subsistence farms in SSA, i.e. the conversion of subsistence farms into commercial farms. This exercise, thus, links structural change theories to micro fundamentals (farm-level productivity). The analysis proceeds as follows. The analysis first determines the growth in agricultural productivity (output) that could result from the commercialization of subsistence farms. Next, using a two-sector general equilibrium model, the study proceeds to quantitatively assess the implications of a rise in agricultural productivity through farm commercialization for labour reallocation. This exercise is purely static and has no dynamic general implications. The derivation of the model is presented in Appendix B section B.3. Readers are also referred to Dennis and İşcan (2009) for detailed explanation of the methodology and derivation of the model.

Table 3.30 reports the results of the analyses for two scenarios: (i) a rise in agricultural productivity $A_a$ by 8.6% as implied by regional TFP differences and (ii) a rise in $A_a$ by 15.2% as implied by the best country

Table 3.30: Potential labour reallocation from the commercialization of subsistence farms

| | Employment Shares | | Scenario 1 | | Scenario 2 | | Weighted Estimate | |
|---|---|---|---|---|---|---|---|---|
| Country | $L_{a,2010}$ | $L_{m,2010}$ | $L_a^{'}$ | $\Delta L_a$ | $L_a^{'}$ | $\Delta L_a$ | Scenario 1 | Scenario 2 |
| Ethiopia | 0.79 | 0.21 | 0.73 | -0.06 | 0.69 | -0.10 | -0.05 | -0.09 |
| Ghana | 0.47 | 0.53 | 0.44 | -0.02 | 0.43 | -0.04 | -0.01 | -0.01 |
| Malawi | 0.74 | 0.26 | 0.69 | -0.05 | 0.65 | -0.09 | -0.04 | -0.06 |
| Nigeria | 0.63 | 0.37 | 0.59 | -0.04 | 0.56 | -0.06 | -0.02 | -0.04 |
| Tanzania | 0.81 | 0.19 | 0.75 | -0.06 | 0.71 | -0.10 | -0.04 | -0.06 |

Note:
Scenario 1 is based on regional estimate of a rise in $A_a$ by 8.60% from Table 3.19
Scenario 2 is based on best country case (Ghana) of a rise in $A_a$ by 15.20% from Table 3.20
Source: Employment data is from the Groningen Growth and Development Center (GDDC)

case (Ghana). The analyses show that farm commercialization could have potential implications for labour reallocation away from agriculture, especially, in Ethiopia, Malawi, and Tanzania. In scenario 1, the model predicts about six percentage points reduction in the share of employment in agriculture in Ethiopia, Malawi, and Tanzania, four percentage points in Nigeria, and two percentage points in Ghana. In terms of actual employment (head-count), this translates into over a million labour reallocation away from agriculture in Ethiopia and Nigeria, and about half a million in Tanzania. In the most optimistic case of scenario 2, this could potentially lead to about 10% labour reallocation away from agriculture in Ethiopia, Malawi, and Tanzania, 6% in Nigeria, and 4% in Ghana. These translate into about two million people leaving agriculture in Ethiopia and Nigeria, and a little over a million in Tanzania.

These results are, however, very optimistic. First, it does not take into account labour already employed in commercial farms who may not necessarily be affected by this policy; it simply assumes that all farm labour are employed in the subsistence sector. Second, it also assumes that all farms transition from subsistence into commercial farms during the commercialization process when in reality this might not necessarily be the case. While some may transition, others may remain, especially, those who regard farming as a way of life rather than a commercial venture. One way to partly address this problem is to weight the potential labour reallocation estimates by the proportion/percentage of farms in the subsistence sector. Table 3.30 columns 8 and 9 present the weighted-average estimates. The results are suggestive of a positive role for agricultural commercialization in the structural transformation process in SSA. The analysis still shows substantial labour reallocation away from agriculture to non-agriculture, especially, in Ethiopia, Malawi, and Tanzania.

## 3.6 Conclusion

Agriculture and raising agricultural productivity is key to accelerating the structural transformation in developing countries. However, while commercialization of agriculture has been made a policy priority to addressing the productivity menace in SSA, its outcome is poorly understood, and there is no systematic evidence on the merits of commercialization in raising productivity. This chapter studies farm-level productivity in five countries in SSA, namely, Ethiopia, Ghana, Malawi, Nigeria, and Tanzania. The chapter distinguishes between two broad farm types, commercial and subsistence farms, and uses a nationally representative cross-sectional data from the Living Standards Measurement Study-Integrated Surveys on Agriculture. Using an empirical production function approach, this chapter tests if there are significant differences in productivity across the subsistence and commercial farm types and quantitatively assesses the implications of farm commercialization for labour reallocation across sectors.

The analysis shows that despite the substantial differences in inputs use, farm types are characterized by similar productivity technology, and there are no significant differences in total factor productivity (TFP) across the subsistence and commercial farm types. At the regional level, the study estimates that TFP is about 10% higher for commercial farms than subsistence farms. Evidence at the country-level shows that in Ghana, TFP is on average, about 15% higher for commercial farms than subsistence farms, and in Tanzania, about 10% higher for commercial farms than subsistence farms. In Ethiopia, Malawi, and Nigeria, the study finds no marked differences in TFP across subsistence and commercial farms. Also, in the most "optimistic", a 15% increase in agricultural productivity through farm commercialization could lead to at most a ten percentage points reduction in the share of employment in agriculture in Ethiopia, Malawi, and Tanzania.

Using a complementary approach based on a stochastic production frontier estimation, the chapter estimates technical efficiency across the farm types. The results show substantial technical inefficiency across both farm types. Farms on average produce about 50% below potential, i.e. relative to best practice farms. A further examination shows that technical inefficiency is more likely driven by land characteristics such as plot sizes than household demographic characteristics such as age, gender, marital status, or education. While land may generally not be scarce in most countries in SSA, high-quality land may be scarce and this could pose severe constraint to farm productivity.

Thus, in summary, the empirical analyses show that subsistence farms, to some extent, do possess sustained advantages over commercial farms, especially, in Ethiopia, Malawi, and Nigeria. The study estimates no substantial differences in TFP across the two farm types, and farms are generally characterized by similar production technology. The majority of farms rely heavily on traditional tools such as cutlasses and hoes for farm production. Irrigation and the use of chemical inputs are low and agricultural production is largely rain-fed which can sometimes be very erratic. Overall then, the call for small-subsistence farms to exit crop production may be misplaced. To raise productivity in agriculture, there must be a uniform shift across all farm types towards the adoption of modern (but sustainable) agricultural inputs, supported by government policies directed to improving farming production techniques across all farm types. Thus, without a broad-based approach, any policy push to commercialization that neglects either farm type may not be effective in addressing the productivity menace in agriculture in SSA.

Also, while the majority of farms, especially in Ethiopia, do have low market orientation, most households have considerable market exposure and knowledge of markets. They simply do not produce a marketable surplus for the market. Moreover, even while TFP differences are not substantial across farm types,a large number of farms remain outside the market economy. Therefore, to gain a better insight and improve our understanding of household decision making, chapter 4 of the dissertation investigates the determinants of transition between subsistence and commercial farming in SSA. In particular, this chapter estimates the likelihood of being a commercial versus a subsistence farmer and the likelihood of transitioning from one farm type to another based on observable farm and household characteristics.

# Chapter 4

## Determinants of Farm Commercialization in Sub-Saharan Africa: Evidence from Nigeria and Tanzania

### 4.1 Introduction

Agriculture remains the backbone of many economies in Sub-Saharan Africa (SSA). The sector accounts for over 50% of total employment in Ethiopia, Malawi, Tanzania, and Zambia. However, agriculture is predominantly subsistence-based, and most farmers produce using rudimentary techniques. There is low mechanization, low adoption of high yield varieties and low fertilizer use, and agricultural productivity is low by international standards.[1] Moreover, even while TFP differences between the subsistence and commercial farm types is negligible, a large number of subsistence-based farms in SSA remains outside the cash economy. National policies have emphasized the need to bring them into the fold of commercialized agriculture, defined as the shift away from subsistence-based agriculture to a market-driven economy.[2] Consequently, agricultural commercialization remains a key policy focus and occupies a central position in national development agenda. This shift is positively correlated with higher use of modern farm inputs

[1]See Diao et al. (2010) and O'Gorman (2015).

[2]See Heltberg and Tarp (2002), Olwande, Mathenge et al. (2011), Randela, Alemu, and Groenewald (2008).

such as chemicals (fertilizer, pesticide, herbicide), high-yielding varieties (HYV) seed, and mechanization, and could catalyze structural transformation.[3]

Due to increase use of market inputs, agricultural commercialization is based on the principle of profit maximization (i.e. maximizing economic return to factors) and characterized by the separation of production decisions from consumption.[4] Subsistence agriculture, on the other hand, is driven by livelihood outcomes and characterized by non-separation of production and consumption decisions.[5] Since production decisions are not separate from consumption decisions, subsistence households are generally regarded as utility maximizers rather than profit maximizers. There are, however, some authors who believe that the predominance of a large number of peasant farmers outside the market economy in developing countries is the result of market failure that severely constrain the ability of subsistence farming households to respond to price incentives[6] Much still remain to be learned about the commercialization process in SSA. Overall, while improving market access and farm commercialization may help induce greater investment, improve productivity, and raise rural households incomes, so far there is little evidence on farm-level factors that stimulate farm commercialization (market participation) in SSA.

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[3]See Pingali and Rosegrant (1995) and Awotide, Karimov, and Diagne (2016).

[4]See Pingali and Rosegrant (1995), Nepal and Thapa (2009), Omiti, Otieno, Nyanamba, McCullough et al. (2009), Martey, Al-Hassan, and Kuwornu (2012).

[5]See Lerman (2004), Martey et al. (2012).

[6]See De Janvry, Fafchamps, and Sadoulet (1991),Randela et al. (2008), Olwande et al. (2011), and Mmbando, Wale, and Baiyegunhi (2015).

This chapter examines the determinants of transitions between subsistence and commercial farming in Nigeria and Tanzania using farm-level panel data from the Living Standard Measurement Survey (LSMS). I use a probit model to estimate the likelihood of being a commercial versus subsistence farmer based on observable characteristics and the likelihood of transitioning from one farm type to the other. In both countries, there is a significant proportion of farms with no market participation in a given year; constitute about 50% of farms in Nigeria and 60% in Tanzania. There is also rich transition dynamics overtime, with a significant proportion of farms transitioning from one farm type to the other. In Nigeria, 40% of the subsistence farms in the first year of the survey (2010) transitioned into commercial farms two years later (2012). Over the same period, 40% of the commercial farms transitioned into subsistence farms. In Tanzania, 30% of subsistence farms in 2008 transitioned into commercial farms in 2012, and over the same period, 40% of the commercial farms transitioned into subsistence farms. The results from the probit estimation show that resource endowments (land, labour, chemical use), inter-cropping, crop type (fruits, vegetables, cash crops), irrigation, farm machinery and animal traction use are the key correlates of farm commercialization. The coefficients on these variables are positive and statistically significant and increase the likelihood of market participation.

On the other hand, household demographic characteristics (gender, marital status, education), geo-climatic conditions and agro-ecological zone, and transaction costs (distance to market and distance to a major road) do not significantly affect market participation and thus are not key correlates of commercialization. These results are reasonably robust across different thresholds of farm commercialization. While several aspects of the findings are consistent with the literature, existing studies have mostly ignored this transition margin, and the present study complements the literature in this regard.

Agriculture in Nigeria and Tanzania are governed by national policies that seek to promote agricultural commercialization. In Nigeria, the policy recognizes agriculture as the key to the country's long-term economic growth and security and is aimed at commercializing agriculture and engaging the rural-poor farmers in global markets (Federal Ministry of Agriculture and Rural Development, 2016). The agricultural policy in Tanzania seeks to transform agriculture from subsistence towards commercialization and modernization through crop intensification, diversification, technological advancement and infrastructural development (Ministry of Agriculture, Food Security and Cooperatives, 2013). However, the implementation of these policies have either been crop selective (as in Nigeria) or severely hampered by financial burdens (as in the case of Tanzania). The agricultural policy in Nigeria, for example, prioritizes improving the productivity of domestically-focused crops such as rice, wheat, and maize, while prioritizing for export markets the production of crops such as cowpeas, cocoa, cashew, cassava, ginger, sesame, oil palm, yams, horticulture (fruits and vegetables), and cotton. In Tanzania, the Ministry of Agriculture, Food Security and Cooperatives (2013) for example cites budgetary allocation as the key challenge confronting the implementation of the agricultural policy.

The existing literature emphasizes demand and supply constraints for the lack of commercialization in SSA. The demand side constraint emphasize lack of incentives by farmers. Lack of incentive is further blamed on low market demand (hence low output prices) for agricultural products, high import competition that put farmers at a disadvantage, or a combination of both factors. Nigeria and Tanzania are both characterized by high population and population growth, and rapid urbanization. There is thus a high demand for food and market opportunities for agricultural products (Ministry of Agriculture, Food Security and Cooperatives, 2013; Akinlade, Balogun, and Obisesan, 2016). Both countries are also part of an integrated global economy with the potential for regional and international market opportunities. Yet, in Nigeria, the discovery of crude oil and the subsequent boom of oil prices led to the neglect of the agricultural sector, and agriculture received less support from the government. Subsequently, the decades that followed saw a decline in agriculture and government resorting to the importation of food products even for agricultural products that were previously exported (Ministry of Agriculture, Food Security and Cooperatives, 2013). Also, illegal food imports deprive farmers, particularly, small-holder farmers sizeable market opportunities (Oguzor, 2014). Moreover, while demand for most crops remains high, insufficient supply-chain integration and post-harvest losses pose severe challenges to both countries. This thus suggests that small-scale agriculture using sustainable farming methods can be a viable alternative to large-scale agricultural commercialization.

On the supply side, the slow pace of commercialization is blamed on factors such as lack of resources and lack of access to market and market information. However, the evidence from the sample of farms suggests that while most farmers seem to have some (good) knowledge about output markets and do not lack "resources" per se, they simply do not produce enough for the market. For example, In Nigeria, about 30% of farms which were previously commercial and participated in output markets transitioned into a subsistence farm and dropped out of the output market. Though farmers' organizations such as cooperatives are important channels for market information to improve farmers bargaining power in input and output markets, these institutions are weak and lack the necessary resources to function effectively (Federal Ministry of Agriculture and Rural Development, 2016; Ministry of Agriculture, Food Security and Cooperatives, 2013). As argued by Oguzor (2014), the majority of farmers prefer to sell in the informal market due to the large margins between farm-gate prices received by farmers and market prices paid by consumers, the difference mainly accruing to intermediaries. In my sample, for example, about 80% of farms who participate in output markets prefer to sell their farm products to relatives, neighbours, and friends rather than in open markets.

The rest of the chapter is as follows. Section 2 presents the literature review. Section 3 presents the methodology and data. Section 4 discusses the results, and section 5 concludes.

## 4.2 Related Literature

This study is related to studies that examine households/farmers market participation decision in SSA. The literature identifies household demographic characteristics, human capital, physical resource endowments, transaction costs, social capital, and agro-ecological potential as the key determinants of commercialization/market participation. These factors either constrain the productivity of farms and decrease market participation or increase the cost of marketing and decrease market participation. For example, Goetz (1992) studies the food marketing behaviour of households in Senegal and identifies high transaction costs as the main determinant of market participation. According to Goetz (1992), better access to market information could increase the likelihood of market participation. Heltberg and Tarp (2002), Randela et al. (2008), and Olwande et al. (2011), on the other hand, identify both productivity constraint and high transaction costs as the main obstacles to the integration of smallholder farmers into the market economy. Heltberg and Tarp (2002), for example, examine the marketing decisions of farmers in Mozambique and find a positive relationship between market participation and crop productivity, farm size, animal traction, and ownership of transportation, and a negative correlation between market participation and the age of household head, distance to a railway, and distance to the Provincial capital. Using data on small-holder cotton farmers in Mpumalanga community in South Africa, Randela et al. (2008) identify access to market information, age, farmers' ability to speak/understand English, dependency ratio, land, ownership of livestock, and ownership of transport as the most important correlates of market participation. Olwande et al. (2011) examine the market participation decision of rural-poor and non-poor households in Kenya and identifies land size and membership in a farmer organization as the key correlates of commercialization.

Muriithi and Matz (2014) provide additional evidence on the likely constraints to market participation by smallholder farmers in horticultural farming in Kenya. They find that commercialization is positively correlated with livestock ownership, rainfall, and distance to the nearest market town, and negatively correlated with household size and the age of household head. In Tanzania, Mmbando et al. (2015) examine the market participation decision of maize and pigeonpea farmers, and using a cross-sectional household-level data, identify the distance to the market, gender, educational level of household head, farm size, membership of a farmer association, and location of the household as the primary correlates of market participation. Awotide et al. (2016) examine the market decision of rice farmers in Nigeria and identify market participation to be positively correlated with gender (the male household head), access to improved seed, years of formal education, and average rice yield. Conditional on participation, the result further suggests a positive relationship between a farmer's welfare and yield, income from rice production, the gender of the household head (male), and years of formal education.

This study differs from past studies in several respects. Unlike Muriithi and Matz (2014), Mmbando et al. (2015), Awotide et al. (2016), I use a nationally representative survey data and cover all major food crops. While Mmbando et al. (2015) and Awotide et al. (2016)) use cross-sectional data to estimate static participation probabilities and do not capture changes over time, I use panel data and panel econometrics technique to estimate the transition dynamics and account for unobservable individual-specific effects. These methodological innovations help identify the dynamic transitions between farm types using time-series data, rather than inferring static correlates of farm commercialization.

## 4.3 Methodology

Market participation is modelled as a two-step decision process (see for example Goetz, 1992; Heltberg and Tarp, 2002; Olwande et al., 2011; Muriithi and Matz, 2014; Mmbando et al., 2015; Awotide et al., 2016). The first stage involves a decision to participate in the market or not. Given participation, the second stage determines the extent of market participation measured by the value of products sold. The key assumption underlying this modelling approach is the separation between the initial decision to participate in the market and the decision of how much to sell conditional on participation. The first stage decision is thus independent of the second stage. Consistent with the literature, the first stage decision process is formulated and estimated using probit model/regression.[7]

### 4.3.1 Model Specification

The discrete probability of market participation by farm $i$ at time $t$ is given as

$$P(C_{it} = 1) = P(Q > \tau) = X_{it}\beta + \varepsilon_{it}, \tag{4.1}$$

where $C_{it} = 1$ if at time $t$, market sales by a farm $Q > 0$ and zero if otherwise; $X_{it}$ are correlates of the probability of market participation; and $\varepsilon_{it}$ is the error term. The full model of market participation by farm $i$ at year $t$ ($C_{it}$) is given as

$$\mathrm{C}_{it} = \beta_0 + \beta_L \ln L_{it} + \beta_T \ln T_{it} + \beta_M \ln M_{it} + \gamma_w \mathbf{W_{it}} + \varepsilon_{it}, \tag{4.2}$$

$L, T, M$ denote labour, land and composite chemicals respectively; $\mathbf{W}_{it}$ are other correlates of market participation such as geo-climatic conditions (rainfall) and agro-ecological zones, farm characteristics (soil

[7] See Heltberg and Tarp (2002); Olwande et al. (2011); Muriithi and Matz (2014); Mmbando et al. (2015); and Awotide et al. (2016).

quality, land ownership, land topology, irrigation, crop type, farm machinery); household demographic characteristics (household size, age, gender, and marital status of the household head); human capital (education level of the household head); and transaction costs (measured as distance to the nearest market and distance to major roads). The probit model in equation (4.2) is estimated using the maximum likelihood technique and the " probit" (for cross-section estimation) and "xtprobit" (for panel estimation) commands in Stata.

### 4.3.2 Data, Sample, and Variable Descriptions

#### Data

Data is from the Living Standard Measurement Survey - Integrated Surveys on Agriculture published by the World Bank. These are nationally representative panel survey data on a cross-section of households (see chapter 3 for details). The study uses a panel dataset from two countries (survey years in parentheses): Nigeria (2010/11 and 2012/13) and Tanzania (2008/09, 2010/11 and 2012/13). The survey defines a household as a person or group of persons that live together in the same dwelling, share same house-keeping arrangements, and are catered for as one unit under one head. The survey reports detailed plot-level data on land use, crops, output, inputs. A household may own one or more parcels of land with each parcel containing one or more "plot". The unit of analysis is a "plot", which is also referred to as a farm. A household

Table 4.1: Sample size distribution by farm types

| | Nigeria | | | | | Tanzania | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | | | 2012 | | 2008 | | | 2012 | |
| Category | All Farms | Subsistence | Commercial | Subsistence | Commercial | All Farms | Subsistence | Commercial | Subsistence | Commercial |
| Number of Farms | 3095 | 1479 | 1616 | 1644 | 1451 | 1616 | 963 | 653 | 910 | 706 |
| % of Farms | 100 | 48 | 52 | 53 | 47 | 100 | 60 | 40 | 56 | 44 |
| Number of Households | 2182 | 920 | 1262 | 1028 | 1154 | 1075 | 491 | 584 | 470 | 605 |
| % of Households | 100 | 42 | 58 | 47 | 53 | 100 | 46 | 54 | 44 | 56 |

Note: A subsistence farm is defined as any farm whereby the household consumes 100% of its farm output.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

member may own one or more plots/farms.

### Sample

The sample consists of a balanced-panel of farms which were present in all survey years and reported positive output. Table 4.1 presents the final distribution of the sample in each survey year. Overall, the sample consists of 3,095 farms in Nigeria and 1,616 farms in Tanzania, and split into subsistence farms (with no market orientation) and commercial farms (with market orientation). The analysis indicates a significant proportion of farms with no market orientation/participation; constitute about 50% of farms in Nigeria and 60% of farms in Tanzania. The analysis also shows a relatively stable composition of farms in any given survey year. In Nigeria, the proportion of subsistence farms marginally increased by 6% and in Tanzania declined marginally by 3%.

However, analyses based on pooled sample or cross-section data can conceal many transition dynamics. For example, it is possible for farms

Table 4.2: Transition probabilities across farm types

| | Nigeria (2010/2012) | | Tanzania (2008/2012) | |
|---|---|---|---|---|
| | Subsistence | Commercial | Subsistence | Commercial |
| Subsistence | 0.6 | 0.4 | 0.7 | 0.3 |
| | (932) | (547) | (663) | (300) |
| Commercial | 0.4 | 0.6 | 0.4 | 0.6 |
| | (712) | (904) | (247) | (406) |

Note: The total number of farms are given in parentheses
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

to transition from subsistence (with no market participation) to commercial (with high market participation) or from commercial to subsistence farm. Table 4.2 presents the transition probabilities/matrices across farm types. The analysis indicates rich transition dynamics with a substantial number of farms transitioning from one farm category to the other. In Nigeria, of the total 1,479 subsistence farms in 2010, 40% (547) transitioned into commercial farms while 60% remained in subsistence. Similarly, of the total 1,616 commercial farms in 2010, 40% (712) transitioned into subsistence farms while 60% retained their commercial status. This shows that in Nigeria, the unconditional probability of transitioning between farm type is about 40%. In Tanzania, of the total 963 subsistence farms in 2008, 30% (300) transitioned into commercial farms in 2012; the remaining 70% retained their subsistence status. By contrast, of the total 653 commercial farms in 2008, 40% (247) transitioned into subsistence farms while the remaining 60% (406) retained their commercial orientation.

## Variable Descriptions

The choice of variables included in the model is guided by empirical considerations (Goetz, 1992; Randela et al., 2008; Olwande et al., 2011; Muriithi and Matz, 2014; Mmbando et al., 2015; Awotide et al., 2016). Below I explain the variables, their measurements, and how they affect market participation / farm commercialization.

### Household demographic characteristics and human capital

The household demographic characteristics include household size, age, gender, and marital status of the household head. Household size is indicative of the production and consumption unit of the household. On one hand, the size of the household determines the household's supply of family labour for farming activities and thus the potential marketable output. On the other hand, higher household size can result in the household consuming a significant proportion of its farm product/output, thus potentially decreasing the likelihood of market participation. Gender captures the potential difference in market orientation between a male and female household head. Age and age squared are indicators of the farmer's experience in farming and as such impact a household's market participation. Young farmers may be more receptive to new products and more inclined towards agricultural commercialization. They may, however, lack the necessary experience. On the other hand, older household heads can be skeptical towards the market. They may regard farming as a way of life rather than commercial activity, hence be less likely to participate in output markets. They, nonetheless, possess an enormous amount of experience in farming. Human capital is proxy by formal education and the level of education of the household head which may increase their commercial success if they choose to participate. Education may enhance the ability of a farmer to utilize market information better and make it more profitable to participate in output markets. A farmer's ability to speak and understand basic English and obtain a high level of education is important; likely to lead to lower transaction costs and enable a resource-poor farmer to engage in trade successfully.

**Resource endowment**

Physical resources include land, farm labour (family and hired), and chemical inputs (fertilizer, pesticide, herbicide). These are expected to increase production and generate production surpluses for the market. Labour comprises the total number of family and hired labour; measured in total working hours per year adjusted for differences in hours work per day. Land is the size of cultivated farmland; measured in hectares. The chemical input comprises the quantity of fertilizer (measured in kilograms), insecticides, and pesticides; though the use of the latter two is usually low. The estimation also controls for the value of land. Land can be used as collateral for credit which may allow farmers to adopt improved technologies and increase productivity. Thus farmers access to loans may increase their market participation.

### Transaction costs

Higher trading costs reduce the market participation of farmers. The study controls for trading costs by the distance to the nearest market and distance to major road. These measures were obtained directly from the survey dataset.

### Geo-climatic conditions and agro-ecological zones

The main geo-climatic variable is rainfall. Agriculture in SSA is heavily rainfall dependent which can be erratic. Rainfall improves farm productivity and as such can generate a marketable surplus. The survey also indicates zones in which farms are located: tropical cold and tropical warm. Relative to tropical cold, it is expected that market participation would be higher for the warm tropical zones.

### Other determinants

In the model, I also control for farm/land characteristics (such as soil quality, land topology, land ownership, inter-cropping, use of farm machinery/animal traction and irrigation, use of improve seeds), crop characteristics (e.g. crop types), and regional differences that either enhance productivity and increase market participation or increase the cost of marketing activities and decrease market participation.

Table 4.3: Comparative analysis on output, input, and productivity across farm types

| | Nigeria | | | Tanzania | | |
|---|---|---|---|---|---|---|
| | Percentage Change (%) | | | Percentage Change (%) | | |
| Category | Pooled | Subsistence | Commercial | Pooled | Subsistence | Commercial |
| Land (Hectares) | -13.17 | -19.47 | -5.80 | 22.51 | 12.72 | 25.44 |
| Labour per Farm (Hours Worked) | 104.54 | 111.90 | 101.52 | -34.10 | -43.83 | -23.46 |
| Land-Labour Ratio | -72.29 | -66.88 | -78.37 | 68.08 | 48.37 | 88.67 |
| Labour per Hectare (Hours Worked) | -2.82 | -16.65 | 18.32 | -47.21 | -58.25 | -15.28 |
| Market Value per Farm ($ PPP) | 11.02 | 12.09 | 15.28 | 81.96 | 55.81 | 85.64 |
| Land Productivity ($ PPP) | -30.55 | 5.19 | -51.47 | 91.97 | 54.88 | 128.09 |
| Labour Productivity ($ PPP) | -75.57 | -70.72 | -77.58 | 142.59 | 133.55 | 139.20 |
| fertilizer per Farm (Kg) | 73.20 | 70.97 | 75.17 | -39.18 | -36.92 | -42.10 |
| fertilizer per Hectare (Kg/ha) | -11.57 | 0.52 | -23.13 | -24.55 | 1.81 | -52.68 |
| Cost of Chemical per Farm ($ PPP) | 10.65 | -10.59 | 31.28 | 49.64 | 29.67 | 57.36 |
| Cost of Chemical per Hectare ($ PPP) | -40.45 | -46.86 | -34.73 | 6.85 | -28.47 | 80.12 |

Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

### 4.3.3 Inputs and Productivity across Farm Types

Table C.1 (see appendix) presents the summary statistics on input use (land, labour, chemical) and farm productivity (land and labour) across subsistence and commercial farms. Data in local currencies are first converted into a common currency using 2012 US dollars purchasing power parity (PPP) obtained from the Pen World Table (PWT) version 8.1. Land productivity is defined as the market value of output per hectare of land. Labour productivity, on the other hand, is defined as the market value of output per farm labour. Similar to the result from chapter 3, the analysis indicates substantial differences in inputs use and land/labour productivity across farm types. Readers are referred to chapter 3 section 3.4.6 for detailed explanation.

Table 4.3 shows the changes in inputs use and farm productivity across the farm types between survey years. In Nigeria, the average plot size declined by about 6% for commercial farms and 20% for subsistence farms. Also, whereas labour and fertilizer use per farm increased in both farm types, labour per hectare declined in subsistence farms, and fertilizer per hectare declined in commercial farms. In terms of productivity, while labour productivity significantly declined in both farm types, land productivity declined only for commercial farms. The large decline in labour productivity is the consequence of a faster rise in labour employment relative to output growth. Labour employment more than doubled compared to output growth of about 15%.

In Tanzania, except in few cases, the dynamics in input use and farm productivity are similar across farm types. For example, the average land size increased in both subsistence and commercial farm. However, labour and fertilizer use per farm declined significantly in both farm types. Yet, most farms experienced significant improvement in both land and labour productivity. Labour productivity more than doubled in both farm types, a combination of higher output growth and declining farm labour use.

## 4.4 Empirical Analysis

In this section, I present two sets of results from the probit model estimation: (i) the likelihood of being commercial versus subsistence farm and the likelihood of transition from one farm type to another; (ii) and the key correlates / determinants of farm market participation/ commercialization.

Table 4.4: Likelihood of market participation estimates from the probit regression

| | Panel Data | Cross-Section | | Transition Farms | |
|---|---|---|---|---|---|
| | (2008-2012) | 2008/2010 | 2012 | Subsistence | Commercial |
| Nigeria | 0.49 | 0.52 | 0.46 | 0.36 | 0.54 |
| Tanzania | 0.41 | 0.40 | 0.45 | 0.31 | 0.62 |

Note: The estimates reported here are the likelihood of market participation by farmers. These are average estimates obtained from the probit regression.
Transition farms denote farms that transition from one farm type to the other. Transition subsistence farms denote subsistence farms that transitioned into commercial between the survey years. Transition commercial are commercial farms that transitioned back into commercial between survey years.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

### 4.4.1 Likelihood of Market Participation

Table 4.4 presents the likelihood/probability estimates from the probit regression in equation (4.2). The estimates are similar and consistent with the unconditional estimates from the data reported in Tables 4.1 and 4.2.[8] For example, while the pooled panel data reports about 50% of farms in Nigeria with market participation, the probit model predicts a 49% likelihood/probability of being a commercial farm. In Tanzania, the proportion of farms with market participation is 43%, and this compares to the likelihood estimate of 41%. Moreover, while Table 4.2 reports about 37% of farms in Nigeria transitioning from subsistence into commercial farms between survey years, the likelihood estimate of transitioning into commercial based on the probit estimation is 36%. In Tanzania, the transition probability estimate based on the raw data and the likelihood estimate from the probit model are broadly consistent;

[8] The unconditional likelihood estimates are based on the relative farm proportions from the sample and do not control for farm or land characteristics.

about 30%.

### 4.4.2 Correlates of Farm Commercialization

The likelihood estimates reported in Table 4.4 gives the average probability of being a commercial farm versus subsistence farm in the sample. There are, however, some household demographic and farm characteristics that could increase or decrease the likelihood of farmers market participation. Tables 4.5 and 4.6 present the results of the probit estimation on the key correlates of farm commercialization in Nigeria and Tanzania. Since the probit model is estimated using the maximum likelihood method, the coefficients of the explanatory variables do not represent the average effects; only provide the direction of the effects. Therefore, the study further estimates the marginal impact of the explanatory variables on the dependent variable. The results are also reported in Tables 4.5 and 4.6 and discussed.[9] Columns 2-7 present the results of the cross-sectional analysis for each survey year.

In Nigeria, the analysis shows that physical endowments (land, labour, chemical), farm/land characteristics (inter-cropping, crop type, irrigation, land topology, farm machinery use), and regional differences are essential for agricultural commercialization. These variables are positive and significant, and increase the likelihood of market participation by farmers. Farmers who are relatively well-endowed in farmland, labour and chemical inputs, commercialize and participate in output

[9] The marginal effect measures the expected change in the odd likelihood ratio of participation to a unit change in any of the independent variables

markets. For example, a unit increase in farm labour use increases the likelihood of market participation by 2% and a unit increase in the size of a farm holding raises the likelihood of farm commercialization by 6%. Also, relative to farms with no irrigation or farm machinery use, farmers reporting irrigation and farm machinery use have a higher likelihood of participating in output markets. Moreover, farmers adopting an inter-cropping system have a higher likelihood of participating in output markets than farms using a single-cropping method. Farmers engaged in inter-cropping typically plant cash crops (such as cocoa and oil palm) for the market and staple crops (e.g. maize, cassava, yam) for household consumption. Also, relative to farmers engaged in tuber or cereal cultivation, farmers producing fruits have a higher likelihood of market participation.

By contrast, farm commercialization is negatively correlated with soil quality (nutrient availability constraint), age, and education level of household heads; decrease the likelihood of market participation. The likelihood of market participation decreases by 11% for farmers reporting severe nutrient availability constraints. While organic and inorganic fertilizers could be addressed to this challenge, not all farmers are able to afford its purchase. In the sample, only 40% of farms use fertilizer. One additional year of experience/age decreases market participation marginally by 0.2%. The average household head age in the sample is about 50 years, and age is indicative of cumulative years of experience. However, older household heads are skeptical about the adoption of modern agricultural technology. Also, while advancement in education is expected to increase the ability of farmers to obtain and process market information, the analysis shows that higher level of education (completion of tertiary) by household head significantly decreases the probability of market participation by about 40%. This observation is likely due to the low proportion of farmers with higher educational levels in the sample. Another explanation is the shift in focus from crop cultivation to off-farm income generation activities by educated farmers. Ouma, Jagwe, Obare, and Abele (2010) estimate a similar adverse effect of higher education on market participation for households in Rwanda and Burundi. Household demographic characteristics (such as size, gender, marital status), rainfall, agro-ecological zone, and transaction costs (distance to major road and nearest market) do not appear to influence market participation. These variables are mostly not statistically significant at conventional levels, or their impacts are at best minimal.

In Tanzania, market participation of farmers is positively correlated with physical endowments (land and labour), inter-cropping, irrigation use, crop type (vegetable and cash crop), and land ownership type (owned); increase the likelihood of market participation. A unit increase in farm labour use and plot size raises the likelihood of market participation by 5% and 6% respectively. Owning a plot assures farmers of land security. They can, therefore, invest in their farmland to

Table 4.5: Correlates of farm commercialization/market participation in Nigeria

| | Cross-Sectional | | | | | | Panel | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2010 | | | 2012 | | | 2010-2012 | | |
| Variables | Coeff. | S.E | Marginal Effect | Coeff. | S.E | Marginal Effect | Coeff. | S.E | Marginal Effect |
| Labour | 0.05 *** | 0.02 | 0.02 | 0.07 *** | 0.02 | 0.03 | 0.05 *** | 0.01 | 0.02 |
| Land | 0.13 *** | 0.02 | 0.05 | 0.16 *** | 0.02 | 0.06 | 0.16 *** | 0.02 | 0.06 |
| Chemical (fertilizer) | 0.02 | 0.01 | 0.01 | 0.07 *** | 0.01 | 0.03 | 0.05 *** | 0.01 | 0.02 |
| Land value | 0.01 | 0.02 | 0.01 | -0.02 | 0.02 | -0.01 | -0.00 | 0.01 | -0.00 |
| Rainfall | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Agro-ecological zone (tropical warm=1) | 0.29 | 0.19 | 0.12 | -0.19 | 0.19 | -0.07 | 0.04 | 0.15 | 0.02 |
| Crop type 1 (cereal=1) | -0.46 *** | 0.07 | -0.18 | -0.41 *** | 0.08 | -0.16 | -0.43 *** | 0.06 | -0.17 |
| Crop type 2 (vegetable=1) | 0.10 | 0.10 | 0.04 | -0.04 | 0.10 | -0.02 | 0.07 | 0.08 | 0.03 |
| Crop type 3 (fruit=1) | 0.90 *** | 0.30 | 0.31 | 0.97 ** | 0.48 | 0.35 | 1.09 *** | 0.28 | 0.37 |
| Crop type 4 (cash crop=1) | 0.41 | 0.27 | 0.16 | 0.57 | 0.46 | 0.22 | 0.54 ** | 0.25 | 0.21 |
| Soil quality 1 (nutrient availability, no constraint = 1) | -0.28 *** | 0.07 | -0.11 | -0.32 *** | 0.07 | -0.13 | -0.34 *** | 0.06 | -0.14 |
| Land topology (plain = 1) | 0.04 | 0.06 | 0.01 | 0.10 * | 0.06 | 0.04 | 0.10 ** | 0.05 | 0.04 |
| Land topology (mountain = 1) | 0.74 *** | 0.21 | 0.26 | 0.48 ** | 0.19 | 0.19 | 0.68 *** | 0.16 | 0.25 |
| Multi-cropping (yes = 1) | 0.21 *** | 0.06 | 0.08 | 0.27 *** | 0.06 | 0.10 | 0.27 *** | 0.05 | 0.11 |
| Irrigation (yes = 1) | 0.13 | 0.15 | 0.05 | 0.47 ** | 0.21 | 0.18 | 0.22 | 0.14 | 0.09 |
| Age of household head (years) | -0.01 *** | 0.00 | -0.00 | -0.00 *** | 0.00 | -0.00 | -0.01 *** | 0.00 | -0.00 |
| Gender of household head (male = 1) | 0.06 | 0.14 | 0.02 | -0.01 | 0.14 | -0.00 | 0.04 | 0.11 | 0.01 |
| Marital status of household head (married = 1) | 0.00 | 0.12 | 0.00 | 0.10 | 0.11 | 0.04 | 0.05 | 0.09 | 0.02 |
| Education 1 (If head ever attended school = 1) | -0.03 | 0.06 | -0.01 | -0.08 | 0.06 | -0.03 | -0.05 | 0.05 | -0.02 |
| Education 2 (If head completed secondary = 1) | -0.02 | 0.07 | -0.01 | -0.10 | 0.08 | -0.04 | -0.06 | 0.06 | -0.02 |
| Education 3 (If head completed tertiary = 1) | -0.41 *** | 0.10 | -0.16 | -0.06 | 0.11 | -0.02 | -0.28 *** | 0.08 | -0.11 |
| Household size | -0.00 * | 0.00 | -0.00 | -0.00 | 0.00 | -0.00 | -0.00 | 0.00 | -0.00 |
| Land ownership type (renting = 1) | -0.17 | 0.10 | -0.07 | 0.18 * | 0.10 | 0.07 | 0.01 | 0.08 | 0.00 |
| Land ownership type (owned = 1) | -0.24 *** | 0.09 | -0.09 | -0.01 | 0.08 | -0.00 | -0.11 * | 0.06 | -0.04 |
| Distance to major road (kms) × 1000 | 3.49 ** | 1.39 | 1.39 | 3.93 | 3.20 | 1.56 | 3.44 ** | 1.39 | 1.37 |
| Distance to nearest market (kms) × 1000 | -0.54 | 0.70 | -0.22 | 0.71 | 0.68 | 0.28 | 0.30 | 0.56 | 0.12 |
| Farm machinery use (yes = 1) | 0.21 *** | 0.06 | 0.08 | 0.14 ** | 0.06 | 0.06 | 0.14 *** | 0.05 | 0.06 |
| Animal traction use (yes = 1) | -0.15 ** | 0.06 | -0.06 | 0.11 | 0.07 | 0.04 | -0.04 | 0.05 | -0.02 |
| Regional dummy (south = 1) | 0.46 *** | 0.09 | 0.18 | 0.58 *** | 0.09 | 0.23 | 0.60 *** | 0.07 | 0.23 |
| Year dummy (2012 = 1) | | | | | | | -0.21 *** | 0.04 | -0.08 |
| Constant | 0.09 | 0.32 | | 0.10 | 0.40 | | 0.12 | 0.28 | |
| N | 3,045 | | | 2,851 | | | 5,896 | | |
| $R^2$ | 0.08 | | | 0.07 | | | - | | |

Note: Asterisks denote significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%. Omitted categories in parentheses: agro-ecological zone (tropical cold = 0), crop type (tuber = 0), land topology (plateau = 0), education (no schooling/completed grade 6 = 0), land ownership type (use for free = 0), regional dummy (north = 0).
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

improve land productivity and produce a surplus for the market. Unlike Nigeria, the agricultural policy in Tanzania does not discriminate against crop types. However, relative to farmers engaged in tuber cultivation, the likelihood of commercialization increases for farmers engaged in cash crop production, likely because of their easy marketability. By contrast, market participation is negatively correlated with soil

Table 4.6: Correlates of commercialization / market participation in Tanzania

| | Cross-Sectional | | | | | | Panel | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2008 | | | 2012 | | | 2008-2012 | | |
| Variables | Coeff. | S.E | Marginal Effect | Coeff. | S.E | Marginal Effect | Coeff. | S.E | Marginal Effect |
| Labour | 0.04 | 0.04 | 0.02 | 0.12 *** | 0.04 | 0.05 | 0.13 *** | 0.03 | 0.05 |
| Land | 0.28 *** | 0.04 | 0.11 | 0.16 *** | 0.03 | 0.06 | 0.25 *** | 0.03 | 0.10 |
| Chemical (fertilizer) | 0.02 | 0.02 | 0.01 | -0.00 | 0.02 | -0.00 | 0.03 ** | 0.01 | 0.01 |
| Land Value | -0.00 | 0.03 | -0.00 | -0.00 | 0.03 | -0.00 | 0.00 | 0.02 | 0.00 |
| Rainfall | -0.00 | 0.00 | -0.00 | -0.00 | 0.00 | -0.00 | -0.00 | 0.00 | -0.00 |
| Agro-ecological zone (tropical warm=1) | -0.09 | 0.08 | -0.04 | -0.03 | 0.08 | -0.01 | -0.01 | 0.07 | -0.00 |
| Crop type 1 (cereal=1) | -0.03 | 0.17 | -0.01 | 0.04 | 0.16 | 0.02 | -0.14 | 0.11 | -0.05 |
| Crop type 2 (vegetable=1) | 0.28 | 0.20 | 0.11 | 0.57 *** | 0.19 | 0.22 | 0.48 *** | 0.14 | 0.19 |
| Crop type 3 (fruit=1) | -0.20 | 0.25 | -0.07 | - | - | - | -0.15 | 0.18 | -0.06 |
| Crop type 4 (cash crop=1) | 1.07 *** | 0.36 | 0.39 | 0.64 * | 0.34 | 0.25 | 0.93 *** | 0.24 | 0.35 |
| Soil quality 1 (nutrient availability, no constraint = 1) | 0.26 ** | 0.13 | 0.10 | 0.21 * | 0.11 | 0.08 | 0.33 *** | 0.11 | 0.13 |
| Soil quality 2 (nutrient retention, no constraint = 1) | -0.65 *** | 0.22 | -0.22 | -0.41 * | 0.21 | -0.16 | -0.79 *** | 0.20 | -0.26 |
| Land topology (plain = 1) | -0.18 ** | 0.08 | -0.07 | -0.02 | 0.08 | -0.01 | -0.08 | 0.07 | -0.03 |
| Land topology (mountain = 1) | -0.12 | 0.12 | -0.05 | 0.18 | 0.12 | 0.07 | 0.05 | 0.11 | 0.02 |
| Multi-cropping (yes = 1) | 0.29 *** | 0.07 | 0.11 | 0.22 *** | 0.07 | 0.09 | 0.39 *** | 0.05 | 0.15 |
| Irrigation (yes = 1) | 0.71 *** | 0.24 | 0.28 | 0.81 *** | 0.27 | 0.32 | 0.79 *** | 0.21 | 0.31 |
| Age of household head (years) | -0.01 *** | 0.00 | -0.00 | -0.01 *** | 0.00 | -0.00 | -0.01 *** | 0.00 | -0.01 |
| Gender of household head (male = 1) | 0.12 | 0.12 | 0.04 | -0.03 | 0.12 | -0.01 | 0.06 | 0.10 | 0.02 |
| Marital status of household head (married = 1) | -0.08 | 0.12 | -0.03 | 0.05 | 0.12 | 0.02 | -0.03 | 0.10 | -0.01 |
| Education 1 (If head ever attended school = 1) | 0.06 | 0.09 | 0.02 | -0.09 | 0.09 | -0.03 | -0.06 | 0.07 | -0.02 |
| Education 2 (If head completed secondary = 1) | 0.02 | 0.16 | 0.01 | -0.43 *** | 0.14 | -0.17 | -0.34 *** | 0.13 | -0.13 |
| Education 3 (If head completed tertiary = 1) | -0.87 | 0.59 | -0.27 | -0.47 | 0.61 | -0.19 | -0.71 | 0.46 | -0.23 |
| Land ownership type (renting = 1) | -0.30 | 0.25 | -0.11 | 0.39 | 0.28 | 0.15 | 0.08 | 0.21 | 0.03 |
| Land ownership type (owned = 1) | 0.20 | 0.14 | 0.07 | 0.44 *** | 0.14 | 0.17 | 0.35 *** | 0.11 | 0.13 |
| Distance to major road (kms) × 1000 | -3.78 ** | 1.82 | -1.46 | 0.58 | 1.68 | 0.23 | -0.54 | 1.62 | -0.21 |
| Distance to nearest market (kms) × 1000 | 0.40 | 0.73 | 0.15 | 0.34 | 0.70 | 0.13 | 0.56 | 0.67 | 0.22 |
| Regional dummy (east = 1) | -0.04 | 0.12 | -0.01 | 0.03 | 0.11 | 0.01 | -0.03 | 0.11 | -0.01 |
| Regional dummy (west = 1) | 0.13 | 0.12 | 0.05 | 0.22 * | 0.11 | 0.08 | 0.23 ** | 0.10 | 0.09 |
| Year dummy (2010 = 1) | | | | | | | 0.20 *** | 0.06 | |
| Year dummy (2012 = 1) | | | | | | | 0.19 *** | 0.06 | |
| Constant | -0.07 | 0.49 | | -0.63 | 0.48 | | -0.71 | 0.37 | |
| N | 1,527 | | | 1,611 | | | 4,753 | | |
| $R^2$ | 0.11 | | | 0.09 | | | - | | |

Note: Asterisks denote significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%. Omitted categories in parentheses: agro-ecological zone (tropical cold = 0), crop type (tuber = 0), land topology (plateau = 0), education (no schooling/completed grade 6 = 0), land ownership type (use for free = 0), regional dummy (central = 0).
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

quality (nutrient retention capacity), age, and education level of household head (head completing secondary); decrease the likelihood of farm commercialization. Though nutrient availability to soil does not appear to be a problem, nutrient retention capacity of the soil do poses a significant constraint to crop productivity and farmers market participation. A year increase in the age of the household head decreases the likelihood of commercialization marginally by 0.4%. The average

age for the household head is about 49 years. While it is possible that older household heads may have acquired better experience in crop selection and market interactions, older heads may also be slow to adopt modern agricultural technology and likely regard farming as a way of life than a commercial venture. Though counterintuitive and similar to the case of Nigeria, a higher level of education (head completing secondary) constrain market participation by farmers. It decreases the likelihood of participation by 43%, and this adverse effect is likely due to the shifting away of resources to off-farm income generating activities by the more educated farmers. Household demographic characteristics (size, gender, marital status), rainfall, agro-ecological zone, distance to major road and closest market do not appear to significantly influence market participation.

However, cross-sectional analysis ignores transition dynamics (change over time) and does not account for unobservable individual-specific effects. To account for these shortfalls, this study estimates the likelihood functions using panel data and panel econometric techniques. The results are presented in Tables 4.5 and 4.6 columns 8-10. Except in a few cases, the results are broadly consistent with the cross-sectional analysis. In Nigeria, the results show that market participation is positively correlated with resource endowments (labour, land, chemicals) and farm characteristics (inter-cropping, crop type (fruits and cash crops), farm machinery use). The results also show that regional differences are important correlates of farm commercialization. A unit

Table 4.7: Correlates of market participation for transition farms in Nigeria

| | Transition Farms | | | | | |
|---|---|---|---|---|---|---|
| | Subsistence to Commercial | | | Commercial to Commercial | | |
| | Coefficient | S.E | Marginal Effect | Coefficient | S.E | Marginal Effect |
| Labour | 0.10 *** | 0.03 | 0.04 | -0.00 | 0.03 | -0.00 |
| Land | 0.10 *** | 0.04 | 0.04 | 0.17 *** | 0.04 | 0.07 |
| Chemical (fertilizer) | 0.08 *** | 0.02 | 0.03 | 0.06 *** | 0.02 | 0.02 |
| Land value | 0.04 | 0.03 | 0.02 | -0.05 * | 0.03 | -0.02 |
| Rainfall | 0.00 | 0.00 | 0.00 | 0.00 * | 0.00 | 0.00 |
| Agro-ecological zone (tropical warm=1) | -0.10 | 0.26 | -0.04 | -0.17 | 0.28 | -0.07 |
| Crop type 1 (cereal=1) | -0.62 *** | 0.13 | -0.23 | -0.23 ** | 0.11 | -0.09 |
| Crop type 2 (vegetable=1) | -0.21 | 0.16 | -0.08 | 0.08 | 0.14 | 0.03 |
| Crop type 3 (fruit=1) | 1.01 * | 0.53 | 0.38 | - | - | - |
| Crop type 4 (cash crop=1) | 0.23 | 0.69 | 0.09 | 0.66 | 0.61 | 0.24 |
| Soil quality 1 (nutrient availability, no constraint = 1) | -0.23 ** | 0.11 | -0.08 | -0.32 *** | 0.10 | -0.13 |
| Land topology (plain = 1) | 0.05 | 0.09 | 0.02 | 0.10 | 0.08 | 0.04 |
| Land topology (mountain = 1) | 0.18 | 0.39 | 0.07 | 0.55 ** | 0.22 | 0.20 |
| Multi-cropping (yes = 1) | 0.26 *** | 0.09 | 0.10 | 0.28 *** | 0.08 | 0.11 |
| Irrigation (yes = 1) | 0.86 *** | 0.31 | 0.33 | 0.10 | 0.29 | 0.04 |
| Age of household head (years) | -0.00 | 0.00 | -0.00 | -0.01 *** | 0.00 | -0.00 |
| Gender of household head (male = 1) | 0.12 | 0.21 | 0.04 | -0.14 | 0.20 | -0.05 |
| Marital status of household head (married = 1) | -0.01 | 0.17 | -0.00 | 0.23 | 0.16 | 0.09 |
| Education 1 (If head ever attended school = 1) | -0.07 | 0.09 | -0.02 | -0.12 | 0.08 | -0.05 |
| Education 2 (If head completed secondary = 1) | 0.12 | 0.12 | 0.05 | -0.28 ** | 0.11 | -0.11 |
| Education 3 (If head completed tertiary = 1) | -0.14 | 0.15 | -0.05 | 0.14 | 0.16 | 0.05 |
| Household size | -0.00 | 0.00 | -0.00 | -0.00 | 0.00 | -0.00 |
| Land ownership type (renting = 1) | -0.03 | 0.16 | -0.01 | 0.38 ** | 0.15 | 0.14 |
| Land ownership type (owned = 1) | 0.01 | 0.11 | 0.00 | -0.03 | 0.11 | -0.01 |
| Distance to major road (kms) × 1000 | 11.28 ** | 4.94 | 4.20 | -1.94 | 4.39 | -0.77 |
| Distance to nearest market (kms) × 1000 | 2.34 ** | 1.01 | 0.87 | -0.54 | 0.96 | -0.21 |
| Farm machinery use (yes = 1) | -0.01 | 0.10 | -0.00 | 0.24 *** | 0.09 | 0.09 |
| Animal traction use (yes = 1) | 0.23 ** | 0.10 | 0.09 | 0.08 | 0.10 | 0.03 |
| Regional dummy (south = 1) | 0.19 | 0.17 | 0.07 | 0.67 *** | 0.12 | 0.25 |
| Constant | -1.43 ** | 0.61 | | 1.10 * | 0.57 | |
| N | 1,394 | | | 1,454 | | |
| $R^2$ | 0.06 | | | 0.08 | | |

Note: Asterisks denote significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%. Omitted categories in parentheses: agro-ecological zone (tropical cold = 0), crop type (tuber = 0), land topology (plateau = 0), education (no schooling/completed grade 6 = 0), land ownership type (use for free = 0), regional dummy (north = 0).
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

increase in physical endowments such as land and labour for example, could increase the likelihood of market participation by 6% and 2% respectively. Also, relative to farms who do not adopt improved farming techniques, the use of agricultural machinery increases the likelihood

Table 4.8: Correlates of market participation for transition farms in Tanzania

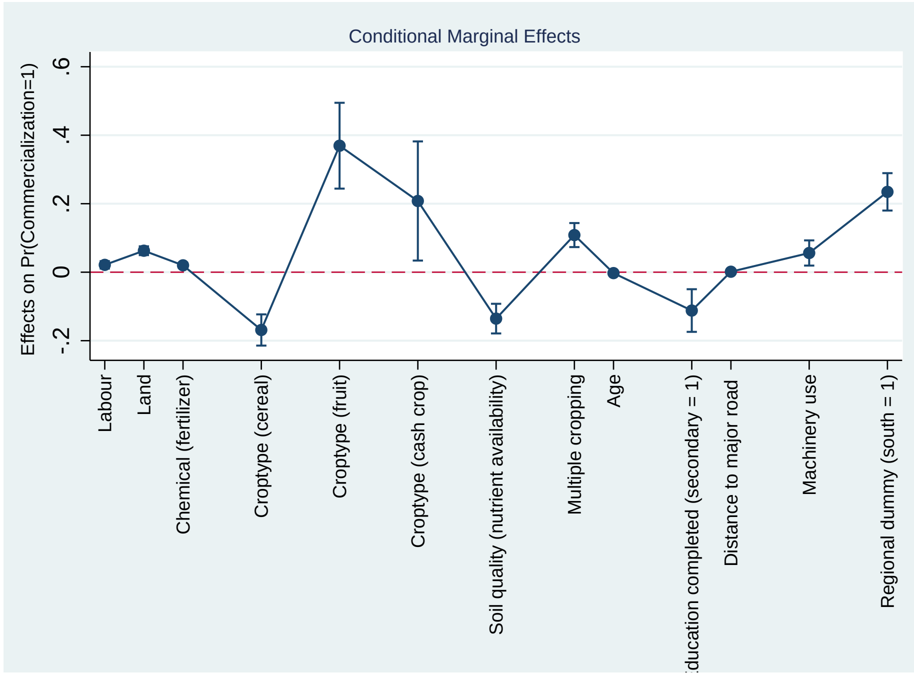
| | Transition Farms | | | | | |
|---|---|---|---|---|---|---|
| | Subsistence to Commercial | | | Commercial to Commercial | | |
| | Coefficient | S.E | Marginal Effect | Coefficient | S.E | Marginal Effect |
| Labour | 0.08 | 0.05 | 0.03 | 0.15 ** | 0.06 | 0.06 |
| Land | 0.17 *** | 0.05 | 0.06 | 0.08 | 0.06 | 0.03 |
| Chemical (fertilizer) | -0.02 | 0.02 | -0.01 | 0.01 | 0.02 | 0.01 |
| Land Value | -0.02 | 0.04 | -0.01 | 0.02 | 0.04 | 0.01 |
| Rainfall | 0.00 | 0.00 | 0.00 | -0.00 | 0.00 | -0.00 |
| Agro-ecological zone (tropical warm=1) | 0.04 | 0.11 | 0.02 | -0.18 | 0.12 | -0.07 |
| Crop type 1 (cereal=1) | -0.21 | 0.19 | -0.07 | 0.33 | 0.28 | 0.13 |
| Crop type 2 (vegetable=1) | 0.52 ** | 0.25 | 0.18 | 0.60 * | 0.33 | 0.20 |
| Crop type 3 (fruit=1) | - | - | - | - | - | - |
| Crop type 4 (cash crop=1) | 0.82 | 0.64 | 0.28 | 0.42 | 0.46 | 0.14 |
| Soil quality 1 (nutrient availability, no constraint = 1) | 0.24 | 0.16 | 0.08 | 0.06 | 0.17 | 0.02 |
| Soil quality 2 (nutrient retention, no constraint = 1) | -0.56 ** | 0.27 | -0.19 | 0.48 | 0.43 | 0.16 |
| Land topology (plain = 1) | -0.04 | 0.10 | -0.01 | 0.03 | 0.12 | 0.01 |
| Land topology (mountain = 1) | 0.22 | 0.16 | 0.08 | 0.08 | 0.19 | 0.03 |
| Multi-cropping (yes = 1) | 0.34 *** | 0.10 | 0.12 | 0.16 | 0.11 | 0.06 |
| Irrigation (yes = 1) | 0.80 * | 0.45 | 0.28 | 0.55 | 0.36 | 0.18 |
| Age of household head (years) | -0.01 *** | 0.00 | -0.00 | -0.01 ** | 0.00 | -0.00 |
| Gender of household head (male = 1) | -0.26 | 0.16 | -0.09 | 0.12 | 0.19 | 0.04 |
| Marital status of household head (married = 1) | 0.34 ** | 0.16 | 0.12 | -0.30 | 0.19 | -0.11 |
| Education 1 (If head ever attended school = 1) | -0.19 | 0.11 | -0.06 | 0.07 | 0.14 | 0.03 |
| Education 2 (If head completed secondary = 1) | -0.50 ** | 0.20 | -0.17 | -0.35 | 0.22 | -0.14 |
| Education 3 (If head completed tertiary = 1) | 0.03 | 0.67 | 0.01 | - | - | - |
| Land ownership type (renting = 1) | 0.52 | 0.32 | 0.18 | - | - | - |
| Land ownership type (owned = 1) | 0.41 ** | 0.19 | 0.14 | 0.31 | 0.21 | 0.12 |
| Distance to major road (kms) × 1000 | 0.62 | 2.29 | 0.21 | 2.43 | 2.72 | 0.92 |
| Distance to nearest market (kms) × 1000 | 0.55 | 0.99 | 0.19 | -0.38 | 1.06 | -0.14 |
| Regional dummy (east = 1) | 0.06 | 0.16 | 0.02 | 0.02 | 0.18 | 0.01 |
| Regional dummy (west = 1) | 0.11 | 0.16 | 0.04 | 0.29 * | 0.17 | 0.11 |
| Constant | -0.38 | 0.64 | | -0.86 | 0.79 | |
| N | 962 | | | 649 | | |
| $R^2$ | 0.10 | | | 0.07 | | |

Note: Asterisks denote significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%. Omitted categories in parentheses: agro-ecological zone (tropical cold = 0), crop type (tuber = 0), land topology (plateau = 0), education (no schooling/completed grade 6 = 0), land ownership type (use for free = 0), regional dummy (central = 0).
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

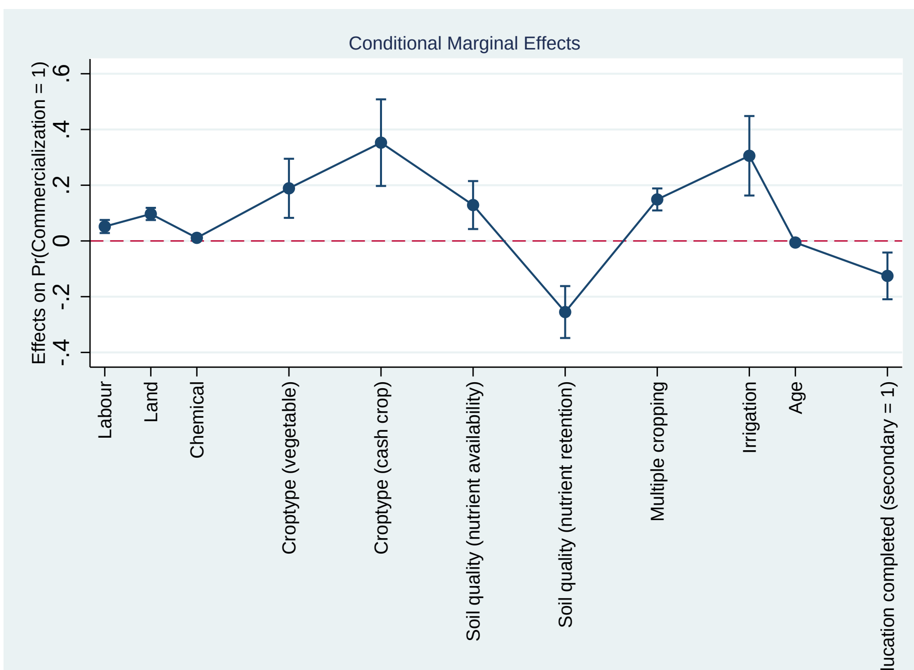
of market participation by 6%. Also, adopting an inter-cropping system could increase the probability of commercialization and market participation by 11%. Irrigation use is positively correlated with market participation. Its impact is, however, not statistically significant. Similarly, household demographic characteristics (size, gender, marital status), rainfall and agro-ecological zone, and transaction cost (distance to closest market) do not appear to affect households market participation decisions. These variables are largely not statistically significant.

In Tanzania, the findings also confirm a positive correlation between market participation and resource endowments (labour, land, chemical), crop type (vegetable and cash crop), inter-cropping, use of irrigation, and land ownership type (owned); significantly increase the likelihood of market participation. A higher endowment of labour and land could increase the likelihood of market participation by 5% and 10% respectively. The additional hectare of land and labour could be committed to expanding crop cultivation, increasing output production, and producing a marketable surplus. Relative to farms operating on freely allocated or rented plots, owning a farmland could increase the likelihood of commercialization by 13%. Also, adopting irrigation and inter-cropping techniques could raise the probability of market participation by 80% and 40% respectively. In most cases, however, household demographic characteristics, rainfall and agro-ecological zone, and transaction cost measures (distance to closest market and major road) do not appear to matter for market participation. The age of the household head, though statistically significant and negatively affects market participation, its impact is minimal; decreases market participation by only 0.5%. Figure 4.1 presents the summary of the marginal effects of the key correlates of farm commercialization in Nigeria and Tanzania.

Figure 4.1: Marginal effects of key correlates of farm commercialization



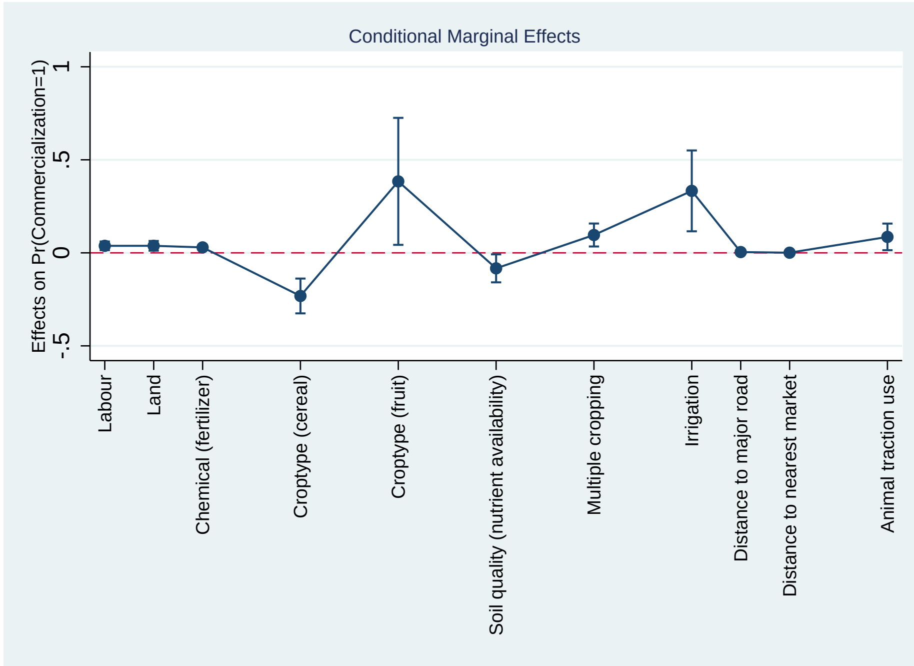

(a) Marginal effects of key correlates (Nigeria)



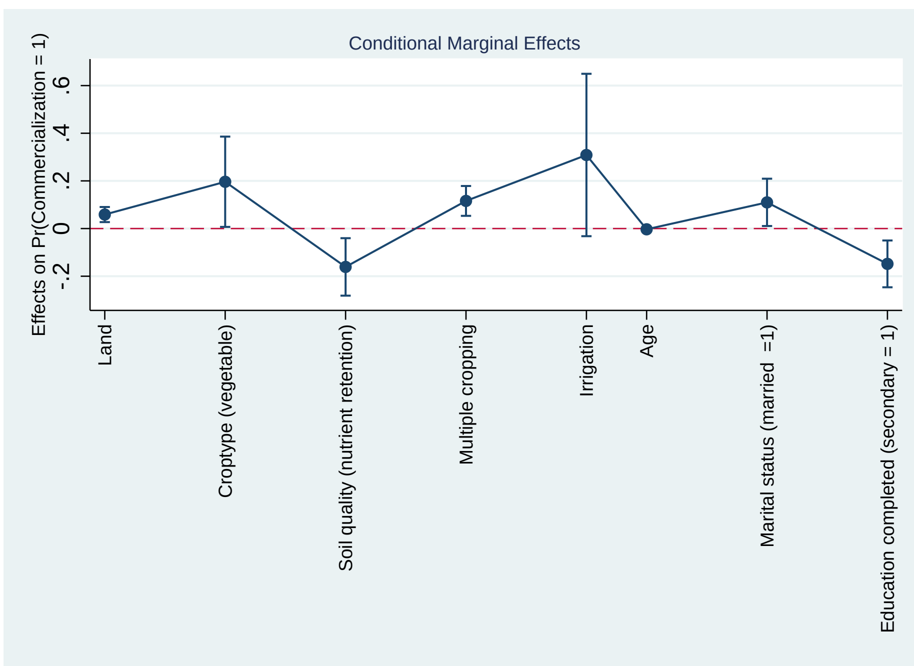

(b) Marginal effects of key correlates (Tanzania)

Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

Figure 4.2: Key correlates of market participation for transitioning subsistence farms




(a) Marginal effects of key correlates of transition (Nigeria)




(b) Marginal effects of key correlates of transition (Tanzania)

Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

The study further explores the panel structure of the data and examine the correlates of market participation for transition subsistence and commercial farm types. The results are presented in Tables 4.7 and 4.8 and are suggestive that resource endowments, farm characteristics, and regional differences are the main determinants of transition. In Nigeria, the market participation of transitioning subsistence and commercial farms[10] is positively correlated with resource endowment (land, labour, chemical) and farm characteristics such as inter-cropping, irrigation, farm machinery use, and animal traction use. The analysis thus shows that increasing resource flow to farmers (especially, subsistence farmers) could increase their likelihood of market participation and thus commercialization. For transitioning subsistence farmers, a unit increase in farm labour or plot size could increase the likelihood of market participation by 4%. Similarly, the likelihood of market participation increases by 33% for irrigation use and 10% for animal traction use and farmer employing an inter-cropping technique. The analysis further reveals the importance of transaction costs for the transitioning of subsistence farms into the market economy. A unit decrease in the distance to major road and getting farmers closer to the market could increase the likelihood of market participation for this farm type by 0.4% and 0.08% respectively. Though the effects appear weak, they nonetheless suggest an important role for physical infrastructure (e.g. road) in the integration of subsistence farms into commercial activities.

[10]The sample of farms transitioning from subsistence to commercial and from commercial to commercial between survey years

In Tanzania, the market participation of transition subsistence farms is positively correlated with land, crop type (vegetable), inter-cropping, irrigation, marital status, and land ownership type (owned). These variables are positive and statistically significant, and increase the likelihood of market participation. It is believed that married household heads are more responsible than unmarried heads. There is also the possibility of pooling resources together with the spouse, especially, labour. Also, farmers with own land could invest in their plots to improve farm productivity and produce a marketable surplus. By contrast, the likelihood of market participation for transition farms decreases for older farmers; an increase in age decreases the likelihood of market participation by about 1%. Figure 4.2 presents the summary of the marginal effects of the key correlates of market participation for transitioning subsistence farms.

### 4.4.3 Robustness Analysis

#### Evidence Based on Different Commercialization Thresholds

Tables C.2 through to C.7 (see appendix) present robustness analyses based on different commercialization threshold rates. Columns 2-7 present the results of the probit estimation for commercialization threshold rates of 20%, 40%, 60%, and 100%. For example, a commercialization threshold rate of 20% classifies farmers that sell 20% or less of their farm output as subsistence farms and greater than 20% as commercial farms. A 100% commercialization threshold rate strictly classifies farmers who sell 100% of their farm products (i.e. have full market participation) as commercial, otherwise subsistence.

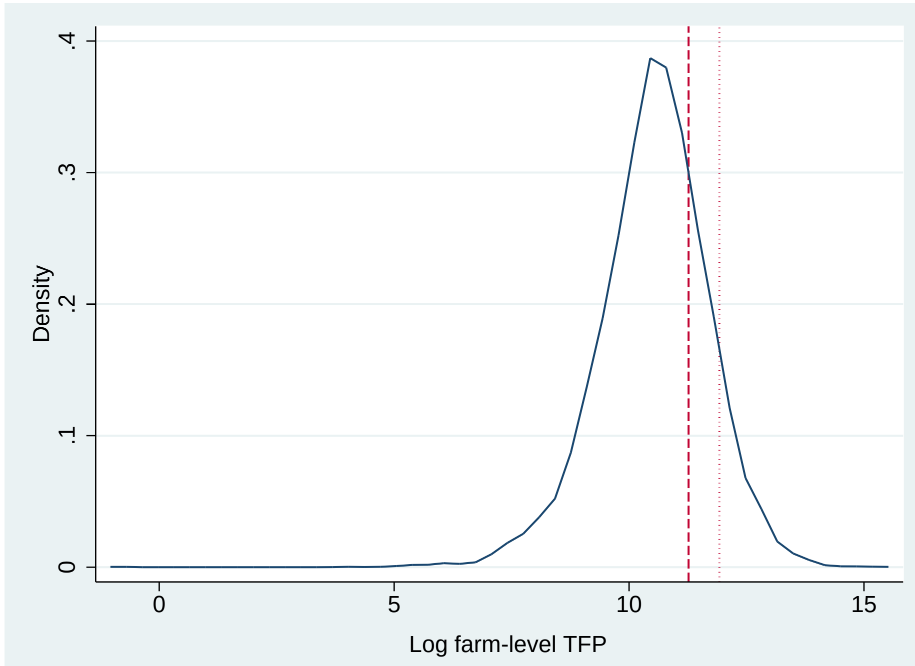
Except in a few cases, the results are relatively robust across different commercialization rates. In Nigeria and for a commercialization threshold rate of 60% or less, market participation is positively correlated with resource endowments (land, labour, chemicals) and farm characteristics such as irrigation, crop types (vegetables, fruits, cash crops) and farm machinery use; these factors increase the likelihood of market participation. The results also suggest an important role for regional differences in accounting for differences in farm commercialization between the northern and southern region. By contrast, market participation is negatively correlated with age, household size, soil quality, and use of animal traction. Also the use of an inter-cropping technique negatively affect market participation. The key correlates of market participation for farms with 100% commercialization rate are land and crop type (vegetable, fruits, cash crops); these factors increase the likelihood of market participation. In Tanzania, the findings are robust across the different thresholds. Market participation is positively correlated with resource endowment (land, chemicals), crop type (vegetable and cash crop), and irrigation use, and negatively correlated with age of household head.

The analysis further reveals some interesting dynamics across the transitioned subsistence and commercial farm types. In Nigeria and for commercialization rate of 40% or less, the market participation of transitioned subsistence farms is positively correlated with resource endowments (labour, land, and chemicals). However, for higher commercialization rates, resource endowments are not significant and do not appear to be critical for market participation. Also, while a unit increase in the use of labour, land, and chemicals significantly increase the likelihood of market participation for transitioned subsistence farms, higher use of labour negatively affects the market participation of transitioning commercial farms. Moreover, for higher commercialization rates, the use of inter-cropping negatively impacts on market participation. In Tanzania, only crop types (vegetable and cash crop) and irrigation use are essential for the market participation of transitioned subsistence and commercial farm types.

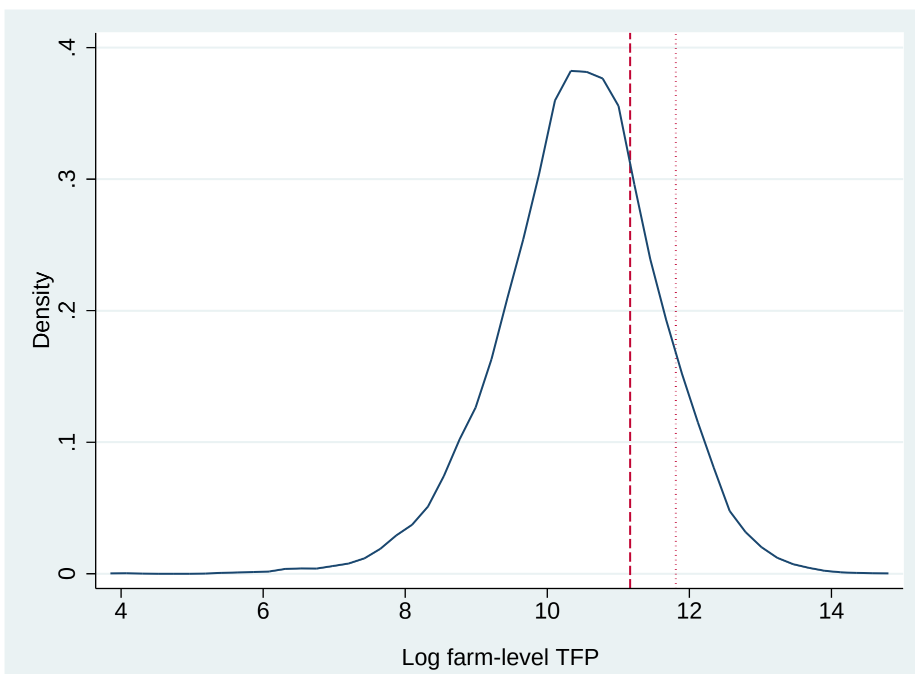
### Evidence Based on High Productivity Farms

The preceding analyses thus further examine the robustness of the baseline result by allowing for some subsistence consideration (i.e. home consumption). Consequently, the analysis classified all farms with no significant market participation (i.e. commercialization rates of 60% and below) as subsistence farms. While the results show that the findings are relatively robust across different commercialization rates, this approach does not distinguish the highly productive farms from the less productive farms. However, one can argue that the decision to

Figure 4.3: Log distribution of farm-level TFP in Nigeria and Tanzania




(a) Log distribution of farm-level TFP in Nigeria




(b) Log distribution of farm-level TFP in Tanzania

Note: The dash line (- - -) denotes 75th percentile and dotted (...) 90th percentile.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

participate in the market to some extent depends on the productivity of the farmer. The more productive farmers are likely to produce a marketable surplus and participate in the output market. The less productive farmers, on the other hand, are more likely to produce for subsistence consideration and stay out of the market economy. Therefore, to examine this hypothesis further, the study first estimates the distribution of TFPs across the farms to identify the highly productive farms in the sample. Figure 4.3 presents the log distribution of farm-level TFP for Nigeria and Tanzania.

The study proceed to examine the correlates of market participation for farms in the 75th percentile and the 90th percentile of the TFP distribution. Tables 4.9 and 4.10 present the results of the probit estimations. In Nigeria, the market participation decision of the highly productive farms is positively correlated with resource endowment (land and chemicals use), inter-cropping, and farm machinery use, and negatively correlated with soil quality, the age of household head, and household size. Also, farmers in Southern Nigeria have a higher likelihood of market participation than farmers in the Northern region. Similarly, in Tanzania, the key correlates of market participation are resource endowment, crop types (vegetable, cash crop), inter-cropping, irrigation use, age and education (completing secondary) of household heads. The highly productive farmers with more endowment of resources (labour, land, chemicals) or engaged in vegetable or cash crop production have a higher likelihood of participating in output markets

Table 4.9: Correlates of commercialization in Nigeria - high productivity farms

| | 75th Percentile of TFP Distribution | | 90th Percentile of TFP Distribution | |
|---|---|---|---|---|
| Variables | Coefficient | S.E. | Coefficient | S.E. |
| Labour | 0.03 | 0.03 | -0.04 | 0.07 |
| Land | 0.14 *** | 0.03 | 0.13 ** | 0.06 |
| Chemical (fertilizer) | 0.08 *** | 0.02 | 0.09 ** | 0.04 |
| Land value | -0.02 | 0.03 | 0.06 | 0.05 |
| Rainfall | -0.00 | 0.00 | 0.00 | 0.00 |
| Agro-ecological zone (tropical warm=1) | -0.05 | 0.30 | 0.37 | 0.52 |
| Crop type 1 (cereal=1) | -0.64 *** | 0.11 | -0.72 *** | 0.24 |
| Crop type 2 (vegetable=1) | -0.49 *** | 0.15 | -0.35 | 0.30 |
| Crop type 4 (cash crop=1) | 0.04 | 0.40 | - | - |
| Soil quality 1 (nutrient availability, no constraint = 1) | -0.29 *** | 0.11 | -0.15 | 0.21 |
| Land topology (plain = 1) | 0.14 | 0.09 | 0.25 | 0.18 |
| Land topology (mountain = 1) | 0.46 ** | 0.21 | 0.18 | 0.35 |
| Multi-cropping (yes = 1) | 0.30 *** | 0.09 | 0.09 | 0.18 |
| Irrigation (yes = 1) | 0.39 | 0.29 | 0.75 | 0.79 |
| Age of household head (years) | -0.01 *** | 0.00 | -0.02 *** | 0.01 |
| Gender of household head (male = 1) | -0.41 | 0.25 | -0.18 | 0.48 |
| Marital status of household head (married = 1) | 0.32 * | 0.19 | 0.62 * | 0.36 |
| Education 1 (If head ever attended school = 1) | -0.11 | 0.09 | -0.50 ** | 0.21 |
| Education 2 (If head completed secondary = 1) | 0.19 | 0.12 | 0.16 | 0.24 |
| Education 3 (If head completed tertiary = 1) | -0.25 * | 0.15 | -0.25 | 0.29 |
| Household size | -0.01 ** | 0.00 | -0.00 | 0.01 |
| Land ownership type (renting = 1) | -0.02 | 0.15 | -0.24 | 0.29 |
| Land ownership type (owned = 1) | -0.28 ** | 0.12 | -0.28 | 0.22 |
| Distance to major road (kms) × 1000 | 0.24 | 2.73 | 14.02 * | 7.29 |
| Distance to nearest market (kms) × 1000 | 1.64 * | 0.98 | 3.28 | 2.09 |
| Farm machinery use (yes = 1) | 0.20 ** | 0.09 | 0.29 | 0.18 |
| Animal traction use (yes = 1) | -0.01 | 0.10 | 0.15 | 0.21 |
| Regional dummy (south = 1) | 0.61 *** | 0.14 | 0.70 ** | 0.31 |
| Year dummy (2012 = 1) | -0.15 * | 0.09 | 0.17 | 0.18 |
| Constant | 1.25 ** | 0.54 | 0.41 | 1.01 |
| N | 1,465 | | 595 | |

Note: Asterisks denote significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

and thus commercializing. Also, irrigation use and adopting an intercropping system increase the likelihood of market participation. By contrast, the likelihood of market participation decreases with the age of household head and education (head completing secondary).

### Evidence at the Household Level

Tables 4.11 and 4.12 provide additional evidence on the correlates of farm commercialization at the household-level rather than the plot-level. The results are fairly consistent and suggest important roles for

Table 4.10: Correlates of commercialization in Tanzania - high productivity farms

| | 75th percentile of TFP distribution | | 90th percentile of TFP distribution | |
|---|---|---|---|---|
| Variables | Coefficient | S.E. | Coefficient | S.E. |
| Labour | 0.32 *** | 0.08 | 0.48 *** | 0.13 |
| Land | 0.24 *** | 0.07 | 0.10 | 0.09 |
| Chemical (fertilizer) | 0.07 ** | 0.03 | 0.10 ** | 0.05 |
| Land Value | -0.00 | 0.06 | 0.05 | 0.09 |
| Rainfall | -0.00 | 0.00 | -0.00 | 0.00 |
| Agro-ecological zone (tropical warm=1) | 0.23 | 0.18 | -0.07 | 0.24 |
| Crop type 1 (cereal=1) | -0.05 | 0.31 | 0.35 | 0.46 |
| Crop type 2 (vegetable=1) | 0.94 ** | 0.37 | 1.20 ** | 0.60 |
| Crop type 3 (fruit=1) | -0.26 | 0.87 | 0.24 | 1.20 |
| Crop type 4 (cash crop=1) | 1.01 ** | 0.50 | 1.20 * | 0.70 |
| Soil quality 1 (nutrient availability, no constraint = 1) | 0.97 *** | 0.30 | 0.40 | 0.41 |
| Soil quality 2 (nutrient retention capacity, no constraint = 1) | -1.24 *** | 0.43 | -0.66 | 0.56 |
| Land topology (plain = 1) | -0.05 | 0.17 | -0.06 | 0.23 |
| Land topology (mountain = 1) | 0.10 | 0.27 | 0.17 | 0.37 |
| Multi-cropping (yes = 1) | 0.48 *** | 0.14 | 0.35 * | 0.21 |
| Irrigation (yes = 1) | 0.80 ** | 0.39 | 0.71 | 0.46 |
| Age of household head (years) | -0.03 *** | 0.01 | -0.03 *** | 0.01 |
| Gender of household head (male = 1) | -0.09 | 0.25 | 0.17 | 0.40 |
| Marital status of household head (married = 1) | -0.06 | 0.25 | -0.69 | 0.43 |
| Education 1 (If head ever attended school = 1) | -0.09 | 0.19 | -0.24 | 0.27 |
| Education 2 (If head completed secondary = 1) | -0.71 *** | 0.26 | -1.12 *** | 0.39 |
| Education 3 (If head completed tertiary = 1) | - | - | - | - |
| Land ownership type (renting = 1) | -0.25 | 0.44 | -0.91 | 0.57 |
| Land ownership type (owned = 1) | 0.69 *** | 0.25 | 0.26 | 0.35 |
| Distance to major road (kms) × 1000 | -2.62 | 3.54 | 8.12 | 5.15 |
| Distance to nearest market (kms) × 1000 | -0.66 | 1.61 | -0.89 | 2.17 |
| Regional dummy (east = 1) | -0.34 | 0.26 | 0.08 | 0.33 |
| Regional dummy (west = 1) | -0.09 | 0.25 | 0.21 | 0.32 |
| Year dummy (2010 = 1) | 0.29 * | 0.17 | 0.48 | 0.29 |
| Year dummy (2012 = 1) | 0.04 | 0.16 | 0.22 | 0.25 |
| Constant | -0.14 | 0.95 | -1.16 | 1.36 |
| N | 1,199 | | 482 | |

Note: Asterisks denote significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

physical endowments and farm characteristics in the commercialization of agriculture in Nigeria and Tanzania. In Nigeria, farm commercialization is positively correlated with land, labour, and chemicals (fertilizer). Households with higher endowments of land and labour, and can afford to purchase fertilizer on plots, expand the scale of operation, and produce marketable surpluses. A unit increase in the household endowment of land and labour could increase the likelihood of market participation by 7% and 3% respectively.[11] Moreover, a hectare increase in the area

[11] Even though larger household sizes decrease the likelihood of market participation (due to higher consumption), its effect is not statistically significant.

Table 4.11: Correlates of farm commercialization in Nigeria: household-level evidence

| | Cross-Sectional | | | | | | Panel | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2010 | | | 2012 | | | 2010-2012 | | |
| Variables | Coeff. | S.E | Marginal Effect | Coeff. | S.E | Marginal Effect | Coeff. | S.E | Marginal Effect |
| Labour | 0.07 *** | 0.02 | 0.03 | 0.11 *** | 0.03 | 0.04 | 0.09 *** | 0.02 | 0.03 |
| Land | 0.19 *** | 0.03 | 0.07 | 0.18 *** | 0.04 | 0.07 | 0.21 *** | 0.03 | 0.08 |
| Chemical (fertilizer) | 0.02 | 0.01 | 0.01 | 0.07 *** | 0.01 | 0.03 | 0.05 *** | 0.01 | 0.02 |
| Land value | 0.01 | 0.02 | 0.00 | -0.02 | 0.03 | -0.01 | -0.01 | 0.02 | -0.00 |
| Rainfall | 0.00 *** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 ** | 0.00 | 0.00 |
| Agro-ecological zone (tropical warm=1) | -0.25 | 0.27 | -0.09 | -0.28 | 0.27 | -0.11 | -0.30 | 0.24 | -0.11 |
| Soil quality 1 (nutrient availability, no constraint = 1) | -0.33 *** | 0.08 | -0.13 | -0.27 *** | 0.08 | -0.11 | -0.36 *** | 0.07 | -0.14 |
| Land topology (plain = 1) | 0.13 * | 0.07 | 0.05 | 0.17 ** | 0.07 | 0.07 | 0.19 *** | 0.06 | 0.07 |
| Land topology (mountain = 1) | 0.61 ** | 0.24 | 0.21 | 0.57 ** | 0.23 | 0.21 | 0.69 *** | 0.21 | 0.23 |
| Age of household head (years) | -0.01 *** | 0.00 | -0.00 | -0.01 ** | 0.00 | -0.00 | -0.01 *** | 0.00 | -0.00 |
| Gender of household head (male = 1) | -0.01 | 0.16 | -0.01 | -0.10 | 0.15 | -0.04 | -0.08 | 0.14 | -0.03 |
| Marital status of household head (married = 1) | -0.08 | 0.14 | -0.03 | 0.07 | 0.13 | 0.03 | 0.04 | 0.11 | 0.01 |
| Education 1 (If head ever attended school = 1) | 0.02 | 0.07 | 0.01 | -0.02 | 0.07 | -0.01 | 0.01 | 0.06 | 0.00 |
| Education 2 (If head completed secondary = 1) | -0.02 | 0.09 | -0.01 | -0.12 | 0.09 | -0.05 | -0.08 | 0.08 | -0.03 |
| Education 3 (If head completed Tertiary = 1) | -0.51 *** | 0.12 | -0.20 | -0.12 | 0.12 | -0.05 | -0.40 *** | 0.11 | -0.16 |
| Household size | -0.00 | 0.00 | -0.00 | -0.00 | 0.00 | -0.00 | -0.00 | 0.00 | -0.00 |
| Distance to major road (kms) × 1000 | 1.36 | 1.65 | 0.53 | 4.93 | 3.90 | 1.95 | 1.85 | 1.74 | 0.72 |
| Distance to nearest market (kms) × 1000 | -0.01 | 0.85 | -0.00 | 1.89 ** | 0.81 | 0.75 | 1.34 * | 0.73 | 0.52 |
| Regional dummy (south = 1) | 0.54 *** | 0.11 | 0.20 | 0.76 *** | 0.11 | 0.29 | 0.79 *** | 0.10 | 0.29 |
| Crop type 1 (area under tuber cultivation) | 0.08 | 0.11 | 0.03 | 0.26 * | 0.14 | 0.10 | 0.14 | 0.09 | 0.06 |
| Crop type 2 (area under cereal cultivation) | -0.13 * | 0.08 | -0.05 | -0.18 ** | 0.08 | -0.07 | -0.14 ** | 0.06 | -0.05 |
| Crop type 3 (area under vegetable cultivation) | 0.03 | 0.09 | 0.01 | -0.02 | 0.13 | -0.01 | 0.02 | 0.08 | 0.01 |
| Crop type 4 (area under fruit cultivation) | 1.46 * | 0.81 | 0.57 | 3.20 ** | 1.43 | 1.27 | 2.60 *** | 0.84 | 1.01 |
| Crop type 5 (area under cash crop cultivation) | 0.27 | 0.43 | 0.10 | 0.35 | 0.22 | 0.14 | 0.33 | 0.22 | 0.13 |
| Area under multi-cropping | 0.08 * | 0.04 | 0.03 | 0.17 *** | 0.06 | 0.07 | 0.11 *** | 0.04 | 0.04 |
| Area under irrigation | -0.08 | 0.14 | -0.03 | -0.01 | 0.19 | -0.00 | -0.06 | 0.12 | -0.02 |
| Proportion of farmland owned | -0.01 | 0.06 | -0.00 | -0.04 | 0.06 | -0.02 | -0.03 | 0.05 | -0.01 |
| Proportion of farmland rented/purchased | 0.04 | 0.07 | 0.02 | -0.01 | 0.09 | -0.00 | 0.04 | 0.06 | 0.01 |
| Area under machinery use | 0.13 *** | 0.04 | 0.05 | 0.11 | 0.07 | 0.04 | 0.14 *** | 0.04 | 0.05 |
| Area uder animal traction use | -0.00 | 0.04 | -0.00 | 0.04 | 0.05 | 0.01 | 0.00 | 0.04 | 0.00 |
| Year dummy (2012 = 1) | | | | | | | -0.24 *** | 0.05 | |
| Constant | 0.60 | 0.39 | | 0.01 ** | 0.49 | | 0.49 | 0.36 | |
| N | 2,148 | | | 2,128 | | | 4,276 | | |
| $R^2$ | 0.10 | | | 0.10 | | | - | | |

Note: Asterisks denote significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%. Omitted categories in parentheses: agro-ecological zone (tropical cold = 0), land topology (plateau = 0), education (no schooling/completed grade 6 = 0), regional dummy (north = 0).
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

of a household farmland under inter-cropping, farm machinery use, or fruit cultivation could increase the likelihood of commercialization by the household. By adopting an inter-cropping system, the household can reduce crop risk (through diversification) and cultivate both staple crops (for home consumption) and cash crops (for markets) concurrently thereby enhancing their commercialization prospects. Increasing the area of farmland under farm machinery use could further enhance

Table 4.12: Correlates of commercialization in Tanzania: household-level evidence

| | Cross-Sectional | | | | | | Panel | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2008 | | | 2012 | | | 2008-2012 | | |
| Variables | Coeff. | S.E | Marginal Effect | Coeff. | S.E | Marginal Effect | Coeff. | S.E | Marginal Effect |
| Labour | 0.10 ** | 0.05 | 0.04 | 0.24 *** | 0.05 | 0.09 | 0.20 *** | 0.04 | 0.08 |
| Land | 0.44 *** | 0.07 | 0.17 | 0.13 ** | 0.06 | 0.05 | 0.30 *** | 0.05 | 0.12 |
| Chemical (fertilizer) | 0.01 | 0.02 | 0.00 | 0.01 | 0.02 | 0.00 | 0.04 *** | 0.01 | 0.02 |
| Land value | -0.04 | 0.04 | -0.02 | -0.05 | 0.03 | -0.02 | -0.03 | 0.03 | -0.01 |
| Rainfall | -0.00 | 0.00 | -0.00 | -0.00 | 0.00 | -0.00 | -0.00 | 0.00 | -0.00 |
| Agro-ecological zone (tropical warm=1) | -0.21 ** | 0.11 | -0.08 | -0.17 * | 0.10 | -0.07 | -0.12 | 0.09 | -0.04 |
| Soil quality 1 (nutrient availability, no constraint = 1) | 0.01 | 0.13 | 0.01 | 0.07 | 0.12 | 0.03 | 0.04 | 0.10 | 0.02 |
| Land topology (plain = 1) | -0.07 | 0.10 | -0.03 | 0.09 | 0.09 | 0.03 | 0.06 | 0.08 | 0.02 |
| Land topology (mountain = 1) | 0.08 | 0.16 | 0.03 | 0.27 | 0.15 | 0.10 | 0.25 ** | 0.12 | 0.09 |
| Age of household head (years) | -0.01 *** | 0.00 | -0.00 | -0.01 *** | 0.00 | -0.00 | -0.02 *** | 0.00 | -0.01 |
| Gender of household head (male = 1) | 0.08 | 0.15 | 0.03 | -0.07 | 0.15 | -0.03 | -0.03 | 0.12 | -0.01 |
| Marital status of household head (married = 1) | 0.01 | 0.15 | 0.00 | 0.09 | 0.15 | 0.03 | 0.09 | 0.12 | 0.03 |
| Education 1 (If head ever attended school = 1) | 0.07 | 0.11 | 0.03 | -0.01 | 0.10 | -0.00 | -0.00 | 0.08 | -0.00 |
| Education 2 (If head completed secondary = 1) | 0.01 | 0.20 | 0.00 | -0.59 *** | 0.16 | -0.23 | -0.47 *** | 0.14 | -0.19 |
| Education 3 (If head completed Tertiary = 1) | -0.86 | 0.65 | -0.33 | -0.54 | 0.65 | -0.21 | -0.76 * | 0.46 | -0.30 |
| Distance to major road (kms) × 1000 | -4.89 ** | 2.20 | -1.90 | 1.06 | 2.05 | 0.41 | -0.16 | 1.78 | -0.06 |
| Distance to nearest market (kms) × 1000 | 1.38 | 0.94 | 0.54 | -0.22 | 0.89 | -0.08 | 0.87 | 0.77 | 0.33 |
| Regional dummy (east = 1) | -0.15 | 0.15 | -0.06 | -0.08 | 0.14 | -0.03 | -0.10 | 0.12 | -0.04 |
| Regional dummy (west = 1) | 0.16 | 0.16 | 0.06 | 0.29 ** | 0.15 | 0.11 | 0.34 *** | 0.12 | 0.13 |
| Crop type 1 (area under tuber cultivation) | -0.08 | 0.27 | -0.03 | 0.14 | 0.20 | 0.05 | 0.01 | 0.12 | 0.00 |
| Crop type 2 (area under cereal cultivation) | 0.04 | 0.17 | 0.02 | 0.03 | 0.13 | 0.01 | -0.01 | 0.10 | -0.00 |
| Crop type 3 (area under vegetable cultivation) | 0.29 | 0.21 | 0.11 | 0.14 | 0.15 | 0.05 | 0.13 | 0.12 | 0.05 |
| Crop type 4 (area under fruit cultivation) | -0.12 | 0.19 | -0.05 | - | - | - | -0.21 | 0.13 | -0.08 |
| Crop type 5 (area under cash crop cultivation) | 1.01 | 0.75 | 0.39 | 0.09 | 0.22 | 0.04 | 0.30 | 0.19 | 0.12 |
| Area under multi-cropping | 0.08 * | 0.05 | 0.03 | 0.09 ** | 0.04 | 0.03 | 0.08 *** | 0.03 | 0.03 |
| Area under irrigation | 1.31 ** | 0.52 | 0.51 | 2.52 * | 1.44 | 0.97 | 1.08 *** | 0.37 | 0.42 |
| Proportion of farmland owned | -0.10 | 0.16 | -0.04 | -0.02 | 0.13 | -0.01 | -0.01 | 0.10 | -0.00 |
| Proportion of farmland rented/purchased | -0.22 | 0.40 | -0.08 | 0.11 | 0.33 | 0.04 | 0.19 | 0.26 | 0.07 |
| Year dummy (2010 = 1) | | | | | | | 0.18 *** | 0.07 | |
| Year dummy (2012 = 1) | | | | | | | 0.20 *** | 0.07 | |
| Constant | 0.79 | 0.54 | | 0.24 | 0.51 | | 0.05 | 0.40 | |
| N | 1,002 | | | 1,071 | | | 3,147 | | |
| $R^2$ | 0.17 | | | 0.14 | | | - | | |

Note: Asterisks denote significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%. Omitted categories in parentheses: agro-ecological zone (tropical cold = 0), land topology (plateau = 0), education (no schooling/completed grade 6 = 0), regional dummy (central = 0).
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

farm productivity and lead to the production of marketable surpluses. Also, committing a larger proportion of the household's farmland to fruit cultivation significantly increases the likelihood of market participation. As explained earlier, this could partly be driven by the country's agricultural policy that prioritizes the production of crops such as fruits for export markets. On the other hand, market participation is negatively correlated with soil quality (nutrient availability constraint) and age of household head. While older household heads are less likely to adopt modern agricultural techniques, poor quality farmlands that lack important plant nutrients are less productive and reduce crop yield.

In Tanzania, the likelihood of market participation is positively correlated with resource endowment (land, labour, chemicals) and the proportion of farmland under inter-cropping and irrigation. By contrast, commercialization is constrained by the age of the household head; decreases the likelihood of market participation. Other household demographic characteristics such as gender, marital status, and education as well as transaction costs variables such as distance to major road and closest market do not appear to matter for market participation.

### 4.4.4 Discussions

The preceding sections 4.4.2 and 4.4.3 present evidence on the important correlates of farm commercialization in Nigeria and Tanzania. The results show that commercialization is positively correlated with resource endowments (land, labour, chemicals) and farm characteristics such as inter-cropping, crop types (fruits, vegetables, and cash crops), irrigation, farm machinery, and animal traction use; increase the likelihood of market participation. A higher endowment of land and labour provides a greater opportunity for marketable surplus and chemicals (e.g. fertilizer) complement land (by providing supplemental nutrients to plants/crops) and raise the productivity of land. However, the increase use of chemicals such as fertilizers could pose a serious environmental hazard to the society. Therefore, the benefits of commercialization through the increase use of chemicals should be weighed against its environmental costs.

While a single-cropping system could yield economies of scale to farmers, an inter-cropping system could be used as a risk management tool by farmers to enhance their market participation. An inter-cropping technique could provide the household with greater crop diversification and reduce the risk of crop failure. However, this cropping method/technique is most relevant for market participation of the purely subsistence farms i.e. farms with 0% commercialization rate. At higher commercialization rates, inter-cropping tends to have adverse effect on market participation.

Also, rainfall in SSA tends to be erratic and unreliable. Therefore, having an irrigation system in place could provide a stable and reliable water supply for crop cultivation, raise farm productivity, and increase the likelihood of market participation and thus commercialization. However, irrigation use comes with its own challenges. For example, using simple irrigation tools such as water cans could be the cheapest and affordable option. This, however, requires more effort on the part of the farmers. Large-scale irrigation projects, on the other hand, could lead to soil salinization over time. Again, the benefits of large-scale irrigation should be weighed against its environmental costs.

Relative to tuber or cereal cultivators, farmers engaged in fruits (Nigeria only), vegetables (Tanzania only) or cash crop production have a likelihood of market participation. While this could likely be due to their easy marketability, in Nigeria, however, this is likely driven by the country's agricultural policy. The policy seeks to prioritize for export markets certain crop types (such as fruits, cocoa, and oil palm) and this may have directly affected farmers crop choice.

The analysis also suggests an important role for regional differences for agricultural commercialization. In Nigeria, relative to farmers in the north, farmers located at the south have a higher likelihood of commercializing. This is not surprising since Northern Nigeria is predominantly savannah and the majority of farmers are pastoral and cultivate mostly staple crops (millet and sorghum). By contrast, the southern region is predominantly rainforest and mangrove, and the majority of farmers grow the country's cash crops (cocoa and oil palm) for export markets.

While several aspects of the findings are broadly consistent with the literature, other results represent novel contributions. The results are broadly consistent with existing studies that emphasize physical endowments as essential determinants for market participation. For example, Olwande et al. (2011) find that larger per capita land size is positively associated with a higher likelihood of market participation by smallholder fruit farmers in Kenya. Akinlade et al. (2016) estimate a positive correlation between farm size and market participation of commercial vegetable farmers in Nigeria. Mmbando et al. (2015) find positive effects for land and labour endowments on market participation of maize and pigeon pea farmers in Tanzania. Similarly, the present study estimates a negative correlation between market participation and age and higher education completed (secondary) by household heads. Muriithi and Matz (2014) also find a similar adverse effect of age and education on the market participation decision of smallholder vegetable farmers in Kenya; the latter though not statistically significant.

However, most of these studies have largely ignored the transition margins. The present study explores the panel structure of the data to focus on transitioning subsistence and commercial farms and contributes to the literature in this regard. The evidence from the probit estimation shows that the market participation decision of transitioning subsistence farms is positively correlated with resource endowment (land, labour, chemicals), inter-cropping, irrigation, and animal traction use. By explicitly controlling for farm characteristics such as crop types, soil quality, cropping method, and irrigation use, the study also provides further exposition on the likely drivers of agricultural commercialization in SSA.

Existing studies have emphasized demand and supply constraints for the slow rate of agricultural commercialization in SSA. On the demand side, the lack of commercialization is blamed on lack of incentives by farmers. On the supply side, the slow pace of commercialization is blamed on factors such as lack of resources and lack of access to market and market information. However, evidence from the study shows that both Nigeria and Tanzania are characterized by large population sizes and high population growth, rapid urbanization, and are part of an integrated global market. There is, therefore, high demands for food and huge market opportunities for agricultural products. Also, most farmers seem to have sufficient knowledge about output markets and do not lack "resources"; they simply do not produce a marketable surplus. In Nigeria for example, about 40% of farms which were previously commercial and participated in output markets transitioned into subsistence farms and dropped out of the output market. In Tanzania, such farms constitute about 30% of the sample. Moreover, even though aware of markets, the majority of farms participating in output markets (about 80%) prefer to sell to relatives, neighbours, and friends rather than in established markets. This observation reinforces a similar view expressed by Mbilinyi (1988). Mbilinyi (1988) challenged the official statistics on Tanzania's crop production and argue that the majority of foodstuffs and grains produced in Tanzania are sold outside official markets. While higher prices can boost production by increasing the returns to inputs, as indicated by Oguzor (2014), a plausible explanation for the high proportion of farmers selling in the informal market may be due to the large margins between farm-gate prices received by farmers and market prices paid by the consumers. The difference mostly accruing to the intermediaries in the supply chain.

## 4.5 Conclusion

This chapter examines the determinants of commercialization and the transition between subsistence and commercial farming in Nigeria and Tanzania. The chapter first estimates the likelihood of being a commercial versus subsistence farmer and the likelihood of transition from subsistence to commercial. Overall, while the analysis indicates a significant proportion of farms with no market participation in any given year (about 50% in Nigeria and 60% in Tanzania), there are also rich transition dynamics over time. Next, modelling farmers market participation decisions, the results from the probit model estimation show that the decision to participate in output market is positively correlated with physical endowments (land, labour, and chemicals (fertilizer)) and farm characteristics such as inter-cropping, crop types (fruits, vegetables, and cash crops), irrigation, and use of farm machinery and animal traction. By contrast, market participation is negatively correlated with the age of household head and soil quality (mostly in Nigeria).

Next, exploring the panel structure of the data, the analysis further reveals rich transition dynamics over time. In Nigeria for example, about 40% of farms transition from one farm type to the other. In Tanzania, 30% of subsistence farms transition into commercial farms and 40% of commercial farms transition into subsistence farms. The study further identifies resource endowments (land, labour, chemicals) and farm characteristics (inter-cropping, irrigation, farm machinery/animal traction use) as the key correlates of market participation for transition subsistence and commercial farms; increase the likelihood of farm commercialization. The findings are relatively robust across different thresholds of farm commercialization.

Overall, the findings are suggestive that policies that improve farmers' access to resources, especially land, could be instrumental in raising productivity in SSA and enhancing farmers ability to exploit market opportunities. The results also highlight an important role for agricultural mechanization in stimulating farm commercialization. Given the positive correlation between market participation and farm machinery and animal traction use, government policies should also be directed to developing the rental market for farm machinery in SSA. This move could enable smallholder farmers who otherwise are not able to afford the outright purchase of farm equipment rent them from the market at affordable prices. The government should also promote the adoption of sustainable agricultural techniques such as the use of inter-cropping systems and extension services. For example, while adopting an inter-cropping system could provide pure the subsistence farmers with greater crop diversification and reduce the risk of crop failure, providing extension services on chemical applications reduce their environmental consequences.

The current development also points to a move toward sustainable smallholder agriculture in SSA as an alternative to large-scale agricultural commercialization. This movement is commendable and a step in the right direction, especially, in the face of the slow pace of commercialization and low use of modern agricultural inputs (chemicals, HYVs, irrigation) and farm mechanization. The diffusion of the green revolution technology in SSA is slow (Pingali, 2012; O'Gorman, 2015) and some authors (O'Gorman, 2015) attribute the region's low productivity in agriculture to this very reason. There are also widespread cases of adverse environmental impacts of the green revolution technology on water use (chemical run-off) and soil degradation documented in India and other Asian countries. This evidence makes it even harder for farmers in SSA to embrace the technology and thus poses a serious threat to the long-term sustainability of the technology in SSA (see for example Pingali, 2012). Moreover, with climate change and climate change adaptability becoming increasingly urgent concerns in SSA, large-scale commercialization does not appear to be a viable and sustainable business model. Instead, smallholder farmers using sustainable and environmentally friendly technology could represent a better viable alternative. Moreover, low government investment in physical infrastructure such as roads has increase the shadow cost and reduce the marginal benefits of modern agricultural technologies, thus reinforcing farmers decision to maintain traditional production systems.

This study is, however, without limitations and the following are worth noting and duly acknowledged. First, the analyses presented in this chapter assume that causality only runs from commercialization to productivity. In reality, there could be a two-way or feedback effects with causality running from productivity to commercialization as well. For example, one could anticipate a situation where increased commercialization could induce farmers to adopt modern inputs and thus improve farm productivity. On the other hand, improvement in productivity could lead to the production of marketable surplus and induce farmers to engage more in commercial activities, thus increase agricultural commercialization. One way to disentangle the two effects is to determine an exogenous policy change which affected either one and trace its effect on the other. Another approach could be to use a controlled experiment but both approaches are beyond the scope of the study. Second, the analyses presented in this chapter are only measures of association or correlation. These correlations should thus be further explored using research designs that more directly speak to causal links running from economic policies to commercialization.

# Chapter 5

# Conclusion

This dissertation examines the economic determinants of labour reallocation in developing countries. It is composed of three interrelated chapters. Chapter 2 documents the historical trends in labour reallocation in 11 countries in SSA and uses a three-sector general equilibrium model to quantitatively assess the importance of standard theories in accounting for labour reallocation in SSA. The model integrates differences in income elasticity of demand across final goods (demand-sided drivers) and differences in sectoral productivity growth combined with complementarities between agriculture and non-agricultural goods (supply-sided drivers). Overall, the analysis shows that structural change has been slow in SSA and this was due to a combination of low productivity level in agriculture, slow (even negative) productivity growth in non-agriculture, and despite these adverse conditions an increasing share of employment in non-agriculture. Moreover, the two channels combine to explain about 50% of the change in the share of employment in agriculture in 40% of the sample, namely, Botswana, Malawi, Mauritius, and South Africa. In the rest of the sample, the explanatory power of the model is weak and in Ethiopia, Kenya, Nigeria, Senegal, and Tanzania, for example, fails to sufficiently account for the labour reallocation . A key conclusion from this chapter is that while labour released by agriculture is critical to structural transformation, low productivity level in agriculture and slow productivity growth in non-agriculture has slowed down the pace of labour reallocation in SSA. This conclusion is reinforced by a counter-factual analysis that replaces productivity growth rates in each sector in SSA with the corresponding sectoral productivity growth rates from South Korea. The result from the counter-factual analysis shows that raising productivity in SSA to levels seen in other rapidly growing economies is essential for faster structural transformation in SSA.

Chapter 3 examines the causes of anemic productivity in agriculture in SSA. This chapter is mainly motivated by the observation that, in many developing countries, agricultural productivity is low by international standard and agricultural commercialization has been made a policy priority to raise productivity in agriculture. However, the causes and consequence of agricultural commercialization in SSA are poorly understood, with no systematic evidence on the merits of commercialization in raising productivity. Using standardized farm-level data from the LSMS-Integrated Surveys on Agriculture, this chapter examines farm-level TFP differences across farm types in five SSA, namely, Ethiopia, Ghana, Malawi, Nigeria, and Tanzania. The study distinguishes between two farm type, commercial and subsistence farms, and using the empirical production function approach tests if TFP is higher in commercial farms than subsistence farms. The findings show that despite the existence of substantial differences in inputs use, subsistence and commercial farms are characterized by similar production technology, and TFP is not significantly different across the two farm types. In the most "optimistic" case of Ghana, TFP is about 15% higher in commercial farms than subsistence farms. A counter-factual analysis of a 15% increase in agricultural productivity through farm commercialization could lead to at most a ten percentage points reduction in the share of employment in agriculture in Ethiopia, Malawi, and Tanzania. A complementary approach based on a stochastic production frontier estimation further reveals substantial technical inefficiency across both farm types and, on average, farms produce about 50% below the benchmark (i.e. best practice farms). Thus, to raise productivity in agriculture, there must be a uniform shift across all farm types towards the adoption of modern (but sustainable) agricultural inputs supported by government policies directed to improving farming production techniques across all farm types.

Chapter 4 of the dissertation examines the determinants of transition between subsistence and commercial farming in Nigeria and Tanzania. This chapter is motivated by the observation that even while TFP difference between the subsistence and commercial farm types is negligible, a large number of subsistence-based farms remains outside the market economy. National policies have, therefore, emphasized the need to bring them into the fold of commercial agriculture. However, the outcome of agricultural commercialization in SSA is poorly understood, and there is little empirical evidence on farm-level factors that stimulate agricultural commercialization in SSA. Using a nationally representative panel data from the Living Standards Measurement Study-Integrated Surveys on Agriculture, this chapter estimates the likelihood of being a commercial versus subsistence farmer and the likelihood of transition from one farm type to another i.e. transitioning from subsistence to commercial farm and vice versa. The analysis indicates that although a substantial proportion of farms has no market participation in a given year (50% in Nigeria and 60% in Tanzania), there are rich transition dynamics over time. The results from the probit regression also show that resource endowments (land, labour, chemical use) and farm characteristics such as inter-cropping, irrigation use, crop type (fruits, vegetables, cash crops) and farm machinery use are positively correlated with the market participation decision of farmers and the transitioning of subsistence farms into a market economy. Overall, policies aimed at improving farmers' access to resources and promoting sustainable smallholder agriculture could be instrumental in raising productivity in agriculture and enhancing marketable agricultural output. These correlates, however, should be further explored using research designs that more directly speak to causality.

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# Appendix A

## Structural Change in Sub-Saharan Africa: A Quantitative Assessment of Traditional Theories

### A.1 Aggregate Labour Growth Decomposition

The aggregate value added in country $j$ at time $t$ is determined as the sum of sectoral value added. Thus,

$$Y_t = \sum_{i=a,m,s} Y_{i,t}$$

where $i = a, m, s$ denote agriculture, industry and services respectively; $Y_t$ and $Y_{i,t}$ denote economy-wide (aggregate) and sectoral value added respectively. We can explicitly determine aggregate value added as:

$$Y_t = Y_{a,t} + Y_{m,t} + Y_{s,t}$$

Dividing through by the aggregate labour force (L), we have that

$$\frac{Y_t}{L_t} = \frac{Y_{a,t}}{L_t} + \frac{Y_{m,t}}{L_t} + \frac{Y_{s,t}}{L_t}$$

$$\frac{Y_t}{L_t} = \frac{Y_{a,t}}{L_t} \times \frac{L_{a,t}}{L_{a,t}} + \frac{Y_{m,t}}{L_t} \times \frac{L_{m,t}}{L_{m,t}} + \frac{Y_{s,t}}{L_t} \times \frac{L_{s,t}}{L_{s,t}}$$

$$\frac{Y_t}{L_t} = \frac{Y_{a,t}}{L_{a,t}} \times \frac{L_{a,t}}{L_t} + \frac{Y_{m,t}}{L_{m,t}} \times \frac{L_{m,t}}{L_t} + \frac{Y_{s,t}}{L_{s,t}} \times \frac{L_{s,t}}{L_t}$$

Denoting employment shares by $\theta$ and labour productivity by $y$

$$y_t = y_{a,t}\theta_{a,t} + y_{m,t}\theta_{m,t} + y_{s,t}\theta_{s,t}$$

The change in aggregate labour productivity at time $t$ can be determined as:

$$y_t - y_{t-1} = (y_{a,t}\theta_{a,t} - y_{a,t-1}\theta_{a,t-1}) + (y_{m,t}\theta_{m,t} - y_{m,t-1}\theta_{m,t-1}) + (y_{s,t}\theta_{s,t} - y_{s,t-1}\theta_{s,t-1}) \tag{A.1}$$

Add and subtract the interactive term $\theta_{i,t-1}y_{i,t}$ on the RHS of equation (A.1). Rearranging yield the change in aggregate labour productivity

$$\begin{aligned} y_t - y_{t-1} = {} & (y_{a,t}\theta_{a,t} - \theta_{a,t-1}y_{a,t}) + (\theta_{a,t-1}y_{a,t} - y_{a,t-1}\theta_{a,t-1}) \\ & + (y_{m,t}\theta_{m,t} - \theta_{m,t-1}y_{m,t}) + (\theta_{m,t-1}y_{m,t} - y_{m,t-1}\theta_{m,t-1}) \\ & + (y_{s,t}\theta_{s,t} - \theta_{s,t-1}y_{s,t}) + (\theta_{s,t-1}y_{s,t} - y_{s,t-1}\theta_{s,t-1}) \end{aligned}$$

$$\begin{aligned} y_t - y_{t-1} = {} & (\theta_{a,t} - \theta_{a,t-1})\, y_{a,t} + (y_{a,t} - y_{a,t-1})\, \theta_{a,t-1} \\ & + (\theta_{m,t} - \theta_{m,t-1})\, y_{m,t} + (y_{m,t} - y_{m,t-1})\, \theta_{m,t-1} \\ & + (\theta_{s,t} - \theta_{s,t-1})\, y_{s,t} + (y_{s,t} - y_{s,t-1})\, \theta_{s,t-1} \end{aligned}$$

$$\begin{aligned} \Delta y_t = {} & (\Delta\theta_{a,t}y_{a,t} + \Delta\theta_{m,t}y_{m,t} + \Delta\theta_{s,t}y_{s,t}) + \\ & (\Delta y_{a,t}\theta_{a,t-1} + \Delta y_{m,t}\theta_{m,t-1} + \Delta y_{s,t}\theta_{s,t-1}) \end{aligned}$$

Therefore, the change in aggregate labour productivity in country $j$ can be determined as:

$$\Delta y_t = \sum_{i=a,m,s} \Delta y_{i,t}\theta_{i,t-1} + \sum_{i=a,m,s} \Delta\theta_{i,t}y_{i,t} \tag{A.2}$$

## A.2 Appendix Tables

Table A.1: Detailed breakdown of the sectors contained in the 10-sector database published by GGDC

| Sub-Sector | Detailed Sub-Sector Description |
|---|---|
| A - Agriculture, hunting and forestry | Agriculture, hunting and related service activities |
| | Forestry, logging and related service activities |
| B - Fishing | Fishing, aquaculture and service activities incidental to fishing |
| C - Mining and quarrying | Mining of coal and lignite; extraction of peat |
| | Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying |
| | Mining of uranium and thorium ores |
| | Mining of metal ores |
| | Other mining and quarrying |
| D - Manufacturing | Manufacture of food products and beverages |
| | Manufacture of tobacco products |
| | Manufacture of textiles |
| | Manufacture of wood and of products of wood and cork, except furniture; |
| | Manufacture of paper and paper products |
| | Manufacture of chemicals and chemical products |
| | Manufacture of rubber and plastics products |
| | Manufacture of machinery and equipment n.e.c. |
| | Manufacture of motor vehicles, trailers and semi-trailers |
| | Manufacture of other transport equipment |
| | Manufacture of furniture; manufacturing n.e.c. |
| E - Electricity, gas and water supply | Electricity, gas, steam and hot water supply |
| | Collection, purification and distribution of water |
| F - Construction | Construction |
| G - Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods | Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel |
| | Wholesale trade and commission trade, except of motor vehicles and motorcycles |
| | Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods |
| H - Hotels and restaurants | Hotels and restaurants |

Detailed breakdown of the sectors contained in the 10-sector database published by the GGDC

| Sub-Sector | Detailed Sub-Sector Description |
|---|---|
| I - Transport, storage, communications | Land transport; transport via pipelines |
| | Water transport |
| | Air transport |
| | Supporting and auxiliary transport activities; activities of travel agencies |
| | Post and telecommunications |
| J - Financial intermediation | Financial intermediation, except insurance and pension |
| | Insurance and pension funding, except compulsory social security |
| | Activities auxiliary to financial intermediation |
| K - Real estate, renting, businesses | Real estate activities |
| | Renting of machinery and equipment without operator and of personal and household goods |
| | Computer and related activities |
| | Research and development |
| | Other business activities |
| L - Public administration and defence; compulsory social security | Public administration and defence; compulsory social security |
| M - Education | Education |
| N - Health and social work | Health and social work |
| O - Other community, social and personal service activities | Sewage and refuse disposal; sanitation and similar activities |
| | Activities of membership organizations n.e.c. |
| | Recreational, cultural and sporting activities |
| | Other service activities |
| P - Activities of private households as employers; undifferentiated production | Activities of private households as employers of domestic staff |
| | Undifferentiated goods-producing activities of private households for own use |
| | Undifferentiated service-producing activities of private households for own use |

Table A.2: Correlation between FAO and GGDC dataset for agriculture

| Country | Correlation |
|---|---|
| Botswana | 0.98 |
| Ethiopia | 0.91 |
| Ghana | 0.91 |
| Kenya | 0.99 |
| Malawi | 0.95 |
| Mauritius | 0.98 |
| Nigeria | 0.13 |
| Senegal | 0.96 |
| South Africa | 0.97 |
| Tanzania | 0.95 |
| Zambia | -0.14 |

Note: Table reports the Pearson's product-moment correlation coefficients for the share of employment in agriculture between the GDCC 10-Sector database and FAO database.
Source: Data are from the 10-Sector Database and FAO Database for the period 1980-2010.

Table A.3: Relative labour productivity in industry and services

| Country | Relative Productivity (Industry) | | | | | Relative Productivity (Services) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1970 | 1980 | 1990 | 2000 | 2010 | 1970 | 1980 | 1990 | 2000 | 2010 |
| Botswana | 37 | 30 | 26 | 40 | 43 | 13 | 11 | 12 | 19 | 18 |
| Ethiopia | 5 | 6 | 7 | 5 | 3 | 5 | 4 | 5 | 7 | 6 |
| Ghana | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| Kenya | 8 | 11 | 7 | 3 | 3 | 7 | 7 | 6 | 4 | 3 |
| Malawi | 9 | 10 | 13 | 7 | 5 | 18 | 30 | 26 | 8 | 5 |
| Mauritius | 4 | 1 | 1 | 1 | 1 | 5 | 3 | 2 | 2 | 2 |
| Nigeria | 5 | 8 | 11 | 16 | 9 | 1 | 2 | 2 | 2 | 1 |
| Senegal | 7 | 9 | 9 | 6 | 5 | 8 | 9 | 7 | 5 | 5 |
| South Africa | 17 | 10 | 8 | 9 | 8 | 16 | 10 | 8 | 7 | 6 |
| Tanzania | 24 | 21 | 19 | 14 | 11 | 19 | 15 | 10 | 8 | 6 |
| Zambia | 18 | 23 | 18 | 11 | 15 | 4 | 10 | 13 | 6 | 10 |
| South Korea | 3 | 3 | 3 | 4 | 3 | 6 | 5 | 3 | 2 | 2 |
| Taiwan | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 |

Note: Productivity levels are measured in constant 2005 PPP US dollars.
Source: Author's calculation based on data from the 10-Sector Database published by the Groningen Growth and Development Center (GGDC) for the period 1970-2010.

Table A.4: Model explanatory power for baseline strategy and broad definitions of industry and services

| | Agriculture | | | | Industry | | | | Services | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Country | Data | Model | % Explained | RMSE (%) | Data | Model | % Explained | RMSE (%) | Data | Model | % Explained | RMSE (%) |
| Botswana | -0.4 | -0.2 | 36.9 | 27.1 | 0.1 | 0.0 | 70.2 | 8.5 | 0.4 | 0.1 | 30.6 | 19.3 |
| Ethiopia | -0.2 | 0.1 | -81.6 | 37.3 | 0.1 | -0.0 | -71.8 | 11.1 | 0.1 | -0.1 | -87.7 | 26.3 |
| Ghana | -0.2 | -0.0 | 31.4 | 13.1 | -0.0 | 0.0 | -862.5 | 3.3 | 0.2 | 0.0 | 3.1 | 12.0 |
| Kenya | -0.3 | -0.0 | 9.0 | 18.4 | 0.1 | 0.0 | 14.3 | 5.7 | 0.2 | 0.0 | 6.2 | 12.8 |
| Malawi | -0.2 | -0.1 | 62.4 | 10.9 | 0.0 | 0.0 | 88.5 | 3.6 | 0.2 | 0.1 | 56.7 | 7.6 |
| Mauritius | -0.3 | -0.2 | 63.4 | 7.2 | 0.1 | 0.1 | 63.8 | 9.1 | 0.2 | 0.1 | 63.2 | 7.5 |
| Nigeria | -0.1 | -0.0 | 32.3 | 11.0 | -0.1 | 0.0 | -27.9 | 6.9 | 0.1 | -0.0 | -0.2 | 7.7 |
| Senegal | -0.2 | 0.5 | -224.5 | 58.5 | 0.1 | -0.1 | -207.5 | 15.3 | 0.2 | -0.4 | -231.8 | 43.2 |
| South Africa | -0.2 | -0.1 | 48.7 | 6.6 | -0.1 | 0.0 | -46.9 | 5.2 | 0.3 | 0.1 | 24.4 | 11.6 |
| Tanzania | -0.2 | -0.2 | 128.0 | 4.9 | 0.0 | 0.1 | 167.0 | 1.5 | 0.1 | 0.2 | 118.8 | 3.7 |
| Zambia | 0.1 | 0.1 | 59.0 | 8.6 | -0.0 | 0.0 | -40.9 | 4.9 | -0.1 | -0.1 | 125.3 | 6.1 |
| South Korea | -0.4 | -0.3 | 70.6 | 10.5 | 0.1 | -0.0 | -20.2 | 11.2 | 0.3 | 0.3 | 93.6 | 3.1 |

Source: Author's calculation based on data from the 10-Sector Database published by the Groningen Growth and Development Center (GGDC) for the period 1970-2010.

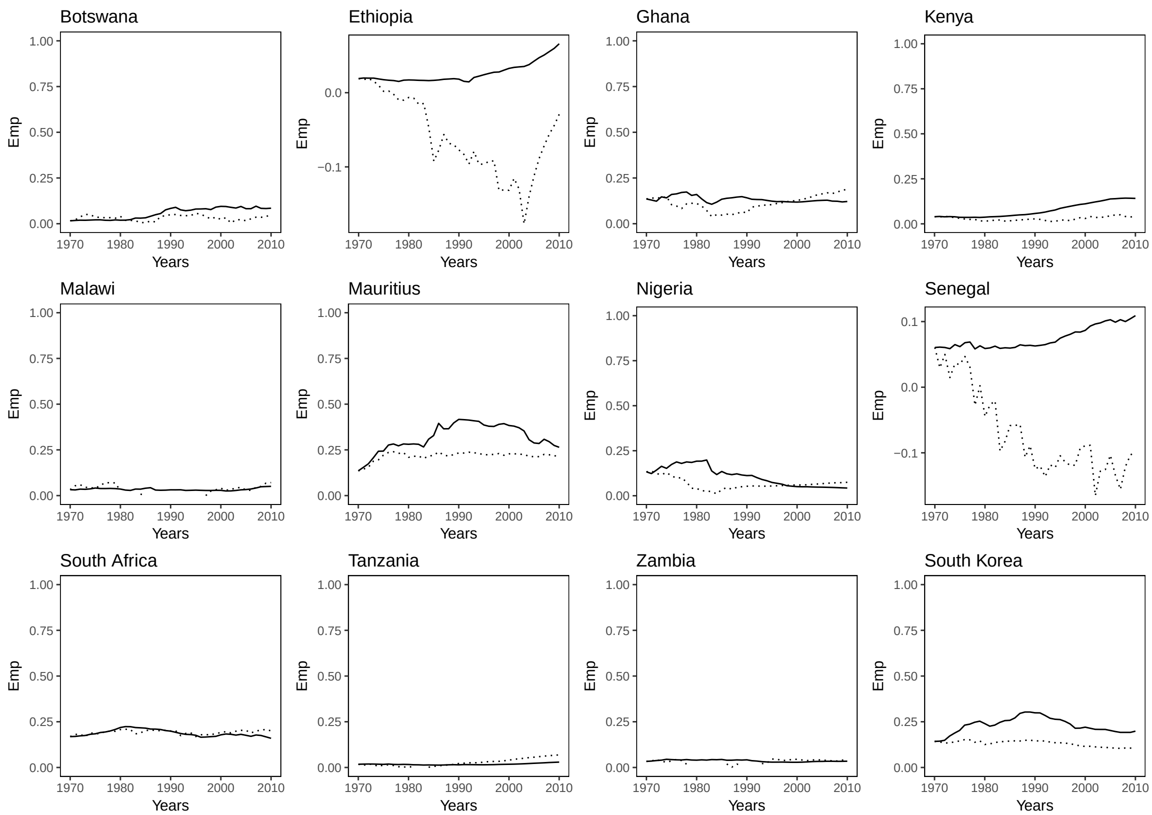
Table A.5: Changes in the share of employment in agriculture for the baseline calibration strategy

| | Narrow Definition of Sectors | | | | Broad Definition of Sectors | | | |
|---|---|---|---|---|---|---|---|---|
| Country | Data | Model | % Explained | RMSE | Data | Model | % Explained | RMSE |
| Botswana | -40.0 | -22.7 | 56.6 | 19.5 | -43.9 | -16.2 | 36.9 | 27.1 |
| Ethiopia | -14.6 | 14.5 | -99.5 | 36.7 | -17.2 | 14.1 | -81.6 | 37.3 |
| Ghana | -17.2 | -6.9 | 40.3 | 16.2 | -15.5 | -4.9 | 31.4 | 13.1 |
| Kenya | -31.4 | -2.2 | 7.0 | 17.7 | -32.7 | -3.0 | 9.0 | 18.4 |
| Malawi | -17.3 | -14.3 | 82.7 | 11.7 | -21.5 | -13.4 | 62.4 | 10.9 |
| Mauritius | -37.7 | -27.8 | 73.7 | 7.8 | -30.1 | -19.1 | 63.4 | 7.2 |
| Nigeria | -5.0 | 2.3 | -45.1 | 12.3 | -6.7 | -2.2 | 32.3 | 11.0 |
| Senegal | -22.0 | 56.1 | -255.3 | 65.2 | -21.8 | 49.0 | -224.5 | 58.5 |
| South Africa | -23.8 | -13.3 | 55.8 | 7.2 | -19.7 | -9.6 | 48.7 | 6.6 |
| Tanzania | -12.9 | -24.0 | 187.0 | 6.2 | -18.0 | -23.0 | 128.0 | 4.9 |
| Zambia | 7.5 | 5.7 | 76.0 | 15.7 | 10.1 | 5.9 | 59.0 | 8.6 |
| South Korea | -43.7 | -33.0 | 75.6 | 9.1 | -42.1 | -29.7 | 70.6 | 10.5 |

Source: Author's calculation based on data from the 10-Sector Database published by the Groningen Growth and Development Center (GGDC) for the period 1970-2010.

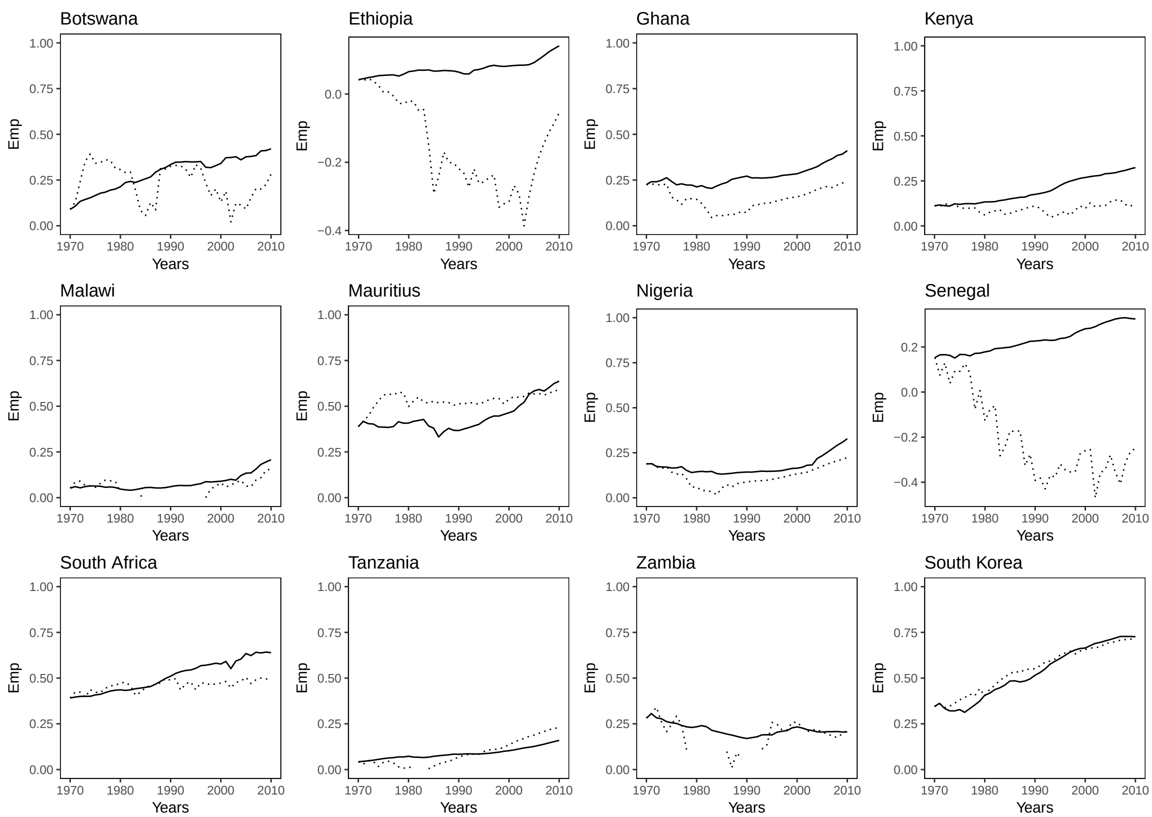
## A.3 Appendix Figures

Figure A.1: The share of employment in manufacturing for the baseline calibration strategy



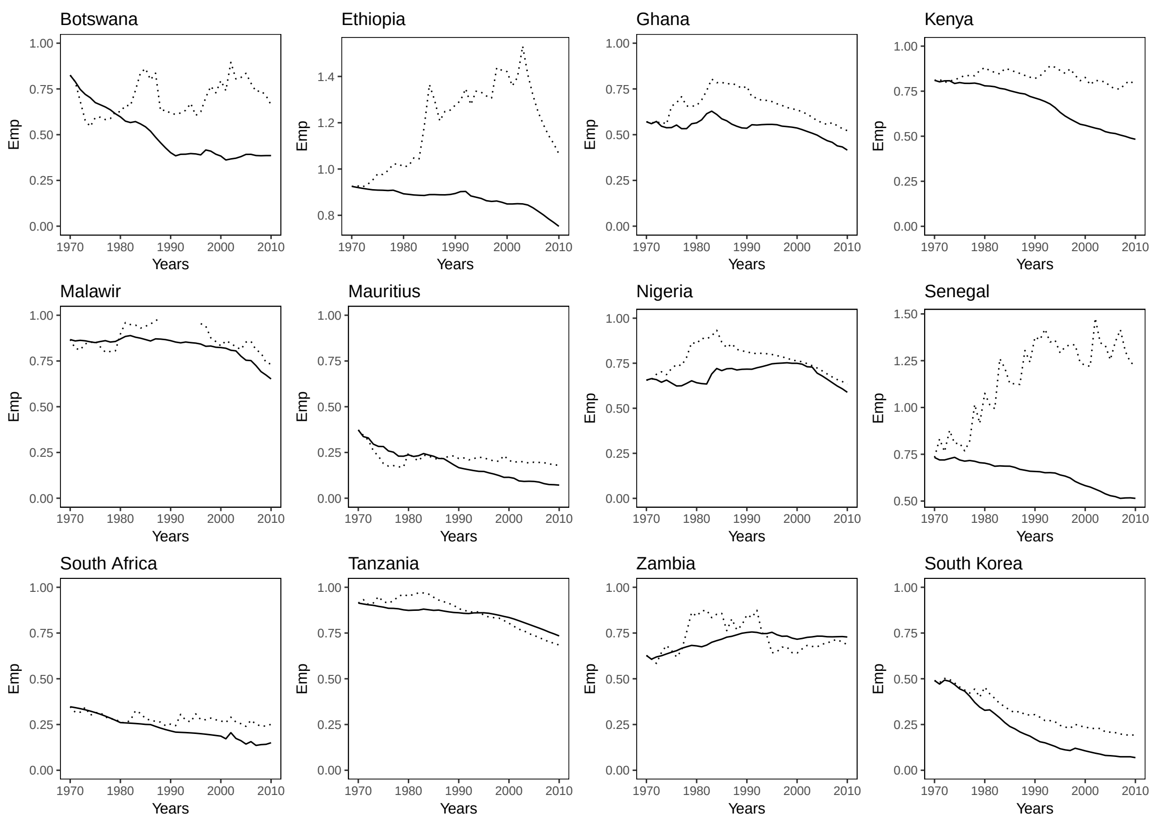

Note: Solid (—) denote data and dotted (...) denotes model-based series.
Source: Data is from the 10-Sector Database published by the Groningen Growth and Development Center (GGDC) for the period 1970-2010.

Figure A.2: The share of employment in services for the baseline calibration strategy



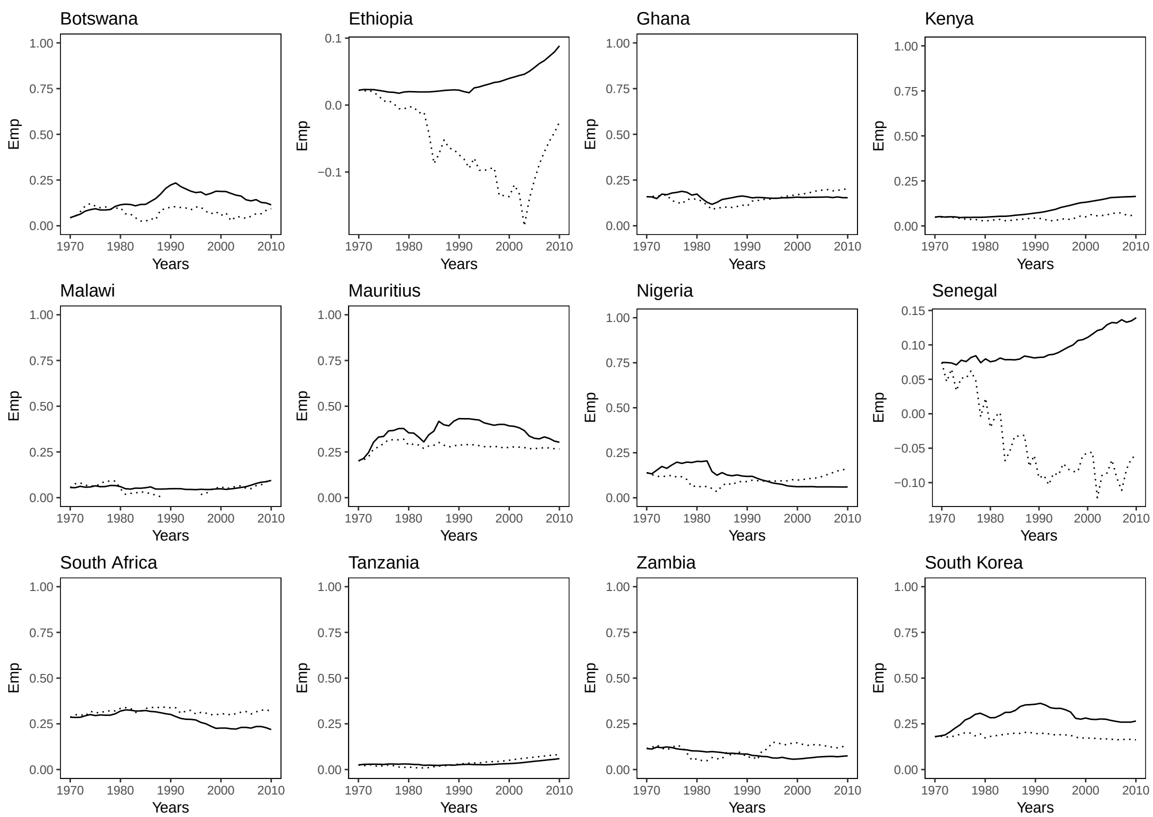

Note: Solid (—) denote data and dotted (...) denotes model-based series.
Source: Data is from the 10-Sector Database published by the Groningen Growth and Development Center (GGDC) for the period 1970-2010.

Figure A.3: The share of employment in agriculture for the broad sectoral classification



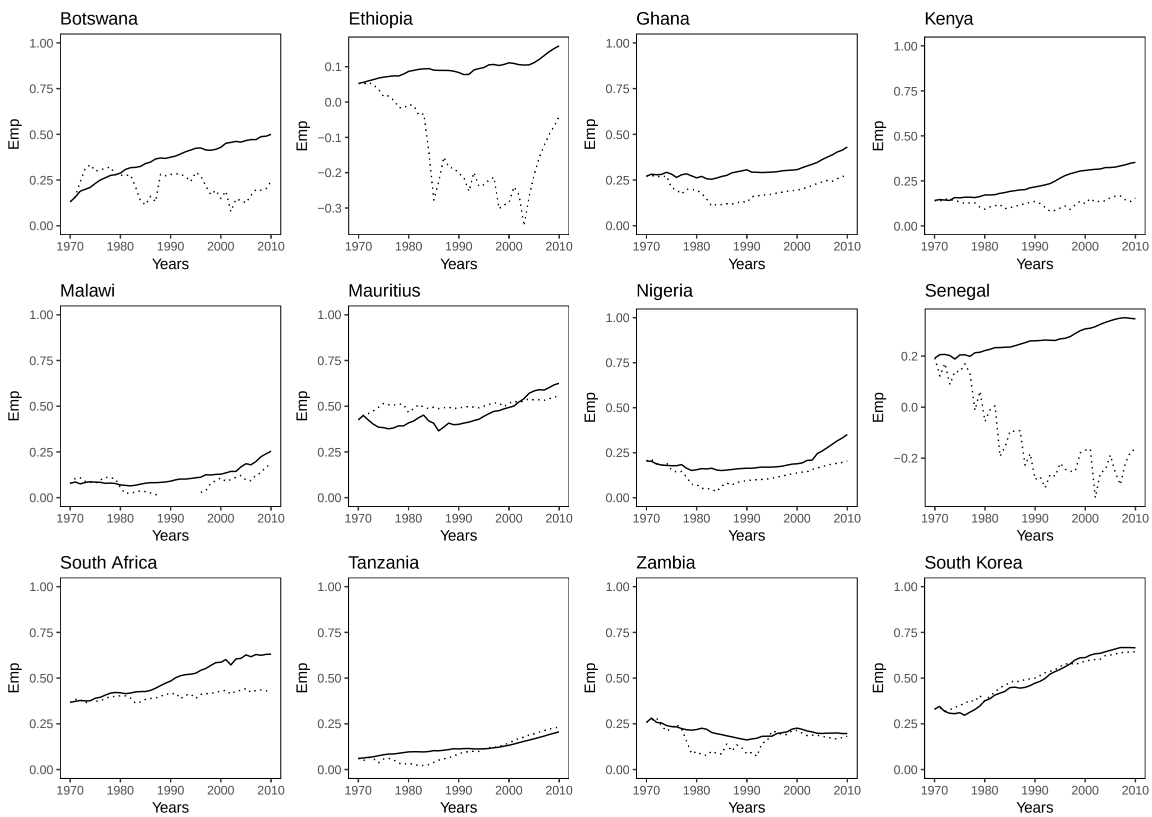

Note: Solid (—) denote data and dotted (...) denotes model-based series.
Source: Data is from the 10-Sector Database published by the Groningen Growth and Development Center (GGDC) for the period 1970-2010.

Figure A.4: The share of employment in industry for the broad sectoral classification




Note: Solid (—) denote data and dotted (...) denotes model-based series.
Source: Data is from the 10-Sector Database published by the Groningen Growth and Development Center (GGDC) for the period 1970-2010.

Figure A.5: The share of employment in services for the broad sectoral classification




Note: Solid (—) denote data and dotted (...) denotes model-based series.
Source: Data is from the 10-Sector Database published by the Groningen Growth and Development Center (GGDC) for the period 1970-2010.

# Appendix B

## Commercialization and Productivity in Agriculture: Micro-level Evidence from Sub-Saharan Africa

### B.1 Data Appendix

This section presents a detailed description of the survey design and data. The data for the study was obtained from the Living Standard Measurement Survey - Integrated Surveys on Agriculture (LSMS-ISA). These survey data collected by various national statistical offices in conjunction with the World Bank LSME-ISA team. These are nationally-representative household surveys implemented every five years with a strong focus on agriculture. This project was established with a grant from the Bill and Melinda Gates Foundation with the primary objective of enhancing statistical research on the link between agriculture and poverty reduction. The key feature of the survey is its focus on agriculture. The survey collects detailed and accurate agricultural data at the household and plot levels on the entire agricultural production system including information on plots/fields areas, crop types and yield, labour and non-labour inputs use (e.g. intermediate inputs such as fertilizers, herbicides, pesticides) and household-farm characteristics for both the principal (rainy) and the minor (dry) seasons.

The study draws on surveys from five SSA countries (survey years in parentheses): Ethiopia (2013/14), Ghana (2009/10), Nigeria (2012/13), Malawi (2013) and Tanzania (2012/13). The survey includes all households and farms engaged in crop production. However, for this study, only households that were engaged in farming activities for the immediate past planting season and reported a positive amount of both output and inputs, particularly, land and labour are considered. Therefore, farms that reported zero output or no labour or land inputs are excluded from the study. In all, the study comprises a sample of 3151 households and a total of 20341 farms for Ethiopia; 2531 households and a total of 4711 farms for Ghana; 3002 households and a total of 6035 farms for Malawi; 2726 households and a total of 4984 farms for Nigeria; and 2864 households and a total of 5236 farms for Tanzania. Stata is the primary statistical package used for the analysis of the data. However, the data on plots, crops and inputs use are located in separate individual files. Therefore, I used the Statistical Package for Social Sciences (SPSS) to merged the different files and re-saved in Stata format for further statistical analysis.

The main variables of interest are output, land, labour, capital, chemical (intermediate) inputs and a number of control variables for geo-climatic conditions (rainfall), land (soil quality, land topology, ecological zones, and land ownership), farm (irrigation, farm-tools and crop types), and farmer characteristics (age, sex, education and the marital status of household heads). Output is measured as the gross market value of the farm products. Market value is preferred to sales or revenue because not all the goods produced by a farmer are sold at the market, some are consumed directly by the farmer. In Malawi and Ethiopia, production by farms is mostly for own consumption with very little agricultural output sold in the market. Output consumed by households in-house are value using the mean at-the-gate prices in each region.

Labour includes the total number of family and hired labour, both on a permanent and casual basis. It is measured in total working hours per year and adjusted for differences in hours of work per day. This measure includes all labour spent on land preparation, planting, weeding, fertilizing, and harvesting on each plot of land. The survey provides information on weeks, days per week, and hours per day employed per plot, and by activity type and individual. Therefore, the total labour requirement per farm is determined by multiplying the average number of hours worked per day by the number of farm workers and the number of weeks worked for each activity. Further adjustment was then made for differences in hours work by assuming a standardized work duration of 8 hours per day. The adjustment was applied to both family, hired, and labour received in exchange or for free. Thus, hours worked by hired labour and free exchange of labour are both included in the estimate of the total labour required for each farm.

Farm-size is the size of cultivated farmland and was measured in hectares. The total farmland owned by the household is determined as the sum of all cultivated household plots irrespective of the status. That is, whether it owned (inherited), rented or purchased. The survey provides two estimates for plots/fields sizes: farmers estimation and GPS coordinated estimates. The GPS measures are used and were preferred to farmers estimation given its high accuracy. However, where conditions do not permit the collection of GPS data, farmers reported estimates were used. I, nonetheless, cross-checked this with the estimates provided by the GPS to check for consistency. In some cases, the correlation analysis shows fairly inconsistent estimates between these two measures. Plots/fields sizes reported in units other than hectares are converted into hectares using the conversion factors provided by the survey administrators. Farms measured in acres and meters are converted into hectares using a conversion factor of 0.4047 and 0.0001 respectively.

Capital in agriculture entails the use of agricultural machinery and farm equipment. However, the data shows minimal use of agricultural machinery in most farms. Hence, the study proxy capital by land value and uses this measure to control for credit constraint. Most lending institutions (banks, credit unions, microfinance) in developing countries require some form of collateral for loan advancement, and for the majority of the poor farming households, the only property they can use to secure this loan is their farmland. Moreover, a correlation analysis shows a very weak correlation between plot sizes and land value. Thus, large farms do not necessarily command high land values neither do small farm-sizes command low values. In fact, what determines the value of a particular farmland largely depend on its quality and proximity. Hence, using land value as a proxy for credit constraint do not pose any significant threat to the estimates of the model parameters.

The composite (intermediate) inputs ideally would comprise the quantity of chemical input (in kilograms) such as fertilizer, insecticide and pesticides used in production. Estimates reported in units other than kilograms (e.g. litres, grams, millimetres, buckets, carts) were converted into kilogram-equivalents. However, the data shows minimal use of chemical inputs, particularly, for pesticides and insecticides. Therefore, the composite chemical input comprises only fertilizer use. However, in order not to lose too many observations, some positive amount of fertilizer is recorded for all farms that otherwise reported zero value and justify this as follow. Farms may not directly use any organic or inorganic chemical input; they use other alternative forms of land complementing inputs such as compost or animal manure.

Also, the estimation controls for several factors that could cause temporary output shocks or variations in productivity across farms such as geo-climates, soil quality, farm or crop characteristics. Rainfall is used as a proxy for geo-climatic condition (an instrument for the unobserved productivity shock) and was measured as total rainfall in millimetres (mm) in the last 12 months. Dummy variable indicators were constructed for some variables relating to land, farm and farmer characteristics to control for other farm productivity shocks. Thus, the detailed level of information on production (output), inputs,


Figure B.1: Survey design structure

geo-climatic and farm/crop characteristics reduces the possibility of substantial mis-measurement and composition bias. Moreover, each household was surveyed twice to reduce recall associated with different aspects of agricultural data collection. Thus, making this database the ideal for measuring productivity (land, labour and total factor productivity) and efficiency across different farm types. Below, I describe in detail the survey design for each country included in the study. Figure B.1 also shows the structure of the survey design for each of the countries. Except for Ghana, the survey designs for the rest of the countries are broadly consistent to aid in a cross-country comparison.

## B.2 Detailed Country Survey Design

### Ethiopia

The Ethiopian Socioeconomic Survey (ESS) is a joint project between the Central Statistics Agency of Ethiopia (CSA) and the World Bank Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) project. The survey collects panel household-level data on household welfare and agricultural activities with the objective of improving agricultural statistics and the link between agriculture and other household income activities. The survey consists of three main questionnaires on household, community and agriculture. The household questionnaire was administered to all households in the sample. The community questionnaire was administered to only a group of community leaders. The agriculture questionnaire comprises three sub-components relating to post-planting, post-harvest, and livestock activities and these were administered to all households engaged in agriculture. Households were visited three times during the agricultural year. The first visit corresponds to the post-planting season and collects data on planting activities. This visit collects detailed data on land ownership and use; farm labour; inputs use; GPS land area measurement; agriculture capital; and irrigation. The second visit implements the livestock module, and the final visit collects data on agricultural production (crop harvest, sales, and utilization) and also implement the household questionnaire. The ESS also include geospatial data collected at the plot and household levels.

The ESS uses a two-stage probability sampling technique. The first stage entails selecting enumeration areas (EAs) from a sample of Annual Agricultural Sample Survey (AgSS) enumeration areas (EAs) using simple random sampling. In all, a total of 433 EAs were selected, and the composition is as follows: rural sample - 290; smaller towns - 43; urban areas - 100. In the second stage, a sample of households to be interviewed in each EA are selected. In rural areas, a total of 12 households were selected from the rural EAs. In small towns, 12 households are selected using simple random sampling from the list of small-town EAs. The urban sample was selected following a multi-stage, clustered design. A total of 15 households were selected from the primary sampling unit using simple random sampling technique. However, due to the problem of non-response, a total of 1,486 households were interviewed.

Households are uniquely identified (*household_id*2) in both the household and agriculture data set, and household-level data files are merged using this unique key variable. Individual within the household are uniquely identified by the variable *individual_id*2 and is used to merge any two individual type files. Additional key variables are, however, required to merge agriculturally related files. For example, parcel files are merged using *holder_id* and *parcel_id* while crop files are merged using *holder_id*, *parcel_id*, *field_id*, and *crop_code*.

**Ghana**

The Ghana Socioeconomic Panel Study Survey is a nationally representative survey of over 5,000 households in Ghana. The survey is a joint effort undertaken by the Institute of Statistical, Social and Economic Research (ISSER) at the University of Ghana, and the Economic Growth Centre (EGC) at Yale University. This project was funded by the Economic Growth Center. The primary objective of the survey is to remedy the major constraint on the understanding of development in low-income countries. The project is set to follow individuals over time using a comprehensive set of survey instruments.

The 2009 survey is the first and only panel wave available at the time of the study. The survey is, however, intended to be implemented every three years. The survey is regionally representative and provides data for the ten regions of Ghana. A two-stage stratified sample design was used for the survey with regions serving as strata. The first stage selects geographical precincts from a master sampling frame. In all, a total of 334 clusters/enumeration areas(EAs) were selected using simple random sampling technique. The number of EAs for each region was proportional to the population share for each region. The second stage selects 15 households from each cluster (EA) using a simple random sampling technique. In all, a total of 5010 households were sampled from 334 Enumeration Areas (EAs). Household files are merged using unique household identification *hhid*; plot files are merged using *hhid* and unique plot identification, and crop files are merged using unique plot and crop identifications.

**Malawi**

Malawi has implemented three integrated household survey so far. The Integrated Household Survey (IHS) is one of the key instruments implemented by the Government of Malawi through the National Statistical Office to monitor and evaluate the changing conditions of Malawian households. The first IHS was implemented with technical assistance from the International Food Policy Research Institute (IFPRI) and the World Bank (WB). The second IHS was implemented with technical assistance from the World Bank. The third IHS expanded on the agricultural content and was implemented in collabouration with the World Bank Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) team. The World Bank LSMS-ISA provided the financial and technical assistance to support the design and implementation of a nationally-representative panel survey with a strong focus on agriculture.

The sample for the third integrated household panel survey (IHPS) was selected to be representative at the national, regional, and urban/rural levels. The final IHPS sample includes a total of 4,000 households that could be traced back to 3,104 baseline households and has an overall attrition rate of 3.78 percent at the household level. At the individual level, the IHPS comprises a total of 14,165 baseline individuals and an overall attrition rate of 7.42 percent at the individual level. The survey design consists of four questionnaire instruments: household questionnaire, agriculture, fishery and community. In order to collect detailed and more accurate information on agricultural inputs and output, the panel households were visited twice in the course of the IHPS fieldwork. The survey also collected detailed set on geospatial variables using the geo-referenced plot and household locations together with various geospatial databases. The agriculture questionnaire was administered to all IHPS households that were identified as being involved in agricultural or livestock activities.

A unique household identifier (*y2_hhid*) in the IHPS data set is used to identify households. It is composed of a given IHPS household's identification value plus the lowest IHS3 two-digit roster ID code for the baseline sample members in 2013. Merging individual-level data requires using a unique variable PID. The PID is assigned to a given individual the first time he/she joined the panel sample. Merging the agricultural files require additional key variables. Plot files are merged using the unique household (*y2_hhid*) and plot (*ag_plotid*) identifications while crop files are merged using *ag_plotid* and a unique crop identification *ag_cropcode*.

### Nigeria

The study uses the second wave of the General Household Survey (GHS) implemented by the National Bureau of Statistics (NBS) in 2012-2013. The GHS-Panel is the result of a collabouration between the Nigeria Federal Ministry of Agriculture and Rural Development, the National Food Reserve Agency, the Bill and Melinda Gates Foundation, and the World Bank. The sample is designed to be representative at the national level and the zonal (urban and rural) level. The GHS-Panel Wave 2 also attempted to track all households that were interviewed in Wave 1 including those that moved to new dwellings or relocated to new communities. In all, the survey consists of 5000 households, and collected detailed data on agricultural activities and other household outcomes. In order to collect accurate data, particularly, on farming activities, the GHS-Panel was carried out in two visits: post-planting and post-harvest.

The survey design consists of three questionnaires for each of the two visits relating to households, agriculture and community. The household questionnaire was administered to all households in the sample while the community questionnaire was administered to selected leaders of the community to collect socio-economic information on the enumeration areas where the surveyed households live. The agriculture questionnaire was administered to all households engaged in agricultural activities including those into crop farming and livestock rearing. The questionnaire collects detailed information on land ownership and use; farm labour; other inputs use; farmer estimates and GPS land area measurement; irrigation; and crop harvest and utilization among others. The survey also collected detailed geospatial data using the georeferenced plot and household locations together with various geospatial databases.

Both the household and agriculture datasets contain a unique household identification variable (*hhid*). This variable is used as the unique key variable in the merging of all household-level files. Individual-level files are merged using a uniquely identified individual ID (*indiv*) and the unique household identification. Other data sets, particularly, agriculture requires additional key variables for merging. For example, plot files are merged using the unique household identification (*hhid*) and *plotid* while crop files are merged using *hhid*, *plotid* and *cropid*.

**Tanzania**

The 2012/2013 Tanzania National Panel Survey (NPS) is the third-panel wave implemented by the Tanzania National Bureau of Statistics (NBS) with the aim of collecting detailed household information on agricultural production, non-farm activities, consumption expenditures, and socio-economic characteristics. The first-panel wave was conducted from October 2008 to November 2009; the second from October 2010 and to September 2011; and the third wave from October 2012 to November 2013. The survey was designed to be national, urban/rural, and agro-ecological zonal representative. The principal funding for the third wave of the NPS was provided by a grant from the European Commission with complementary funding and technical assistance from the World Bank through the Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) program.

The third NPS wave consists of four survey instruments relating to households, agriculture, livestock/fishery, and the community. The NPS data also contains a detailed set of geospatial variables compiled using the geo-referenced plot and household locations in collabouration with various geospatial databases. A total of 3,265 households clustered in 409 enumeration areas (EAs) were included in the first-panel wave in 2009. The NPS 2012/2013 revisited all households interviewed during the first two waves. In all, a total of 2010 households were surveyed for the 2012/13 NPS including the original sample and split-off households and had a household attrition rate of about 5% between the 2008/2009 and 2012/2013 panel waves.

Like many other survey data, the NPS consists of several data files. At the aggregate level, households are identified by a unique seven digit number labelled *y3_hhid*. Individuals also have unique identification numbers and merging individual-level files require using the unique household and individual identification variables. Merging agriculture-related files at the plot level requires using the unique household identification and the plot number "plotnum" identification and at the crop level, the household identification and a crop id "zaocode."

## B.3 Farm Commercialization and Labour Reallocation

### The Model

The model under consideration integrates differences in sectoral productivity growth and differences in income elasticity of demand across sectors' final output. The preference of the representative household is defined over consumption of agriculture ($c_{at}$) and non-agricultural ($c_{mt}$) goods

$$u(c_{at}, c_{mt}) = \left[ \sum_{i=a,m} \gamma_m (c_{mt})^{\frac{\varepsilon-1}{\varepsilon}} + \gamma_a (c_{at} - \bar{c_a})^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}. \tag{B.1}$$

$\bar{c_a} > 0$ is the subsistence consumption requirement (food); $\gamma_i$ denotes expenditure shares; and $\varepsilon$ is the elasticity of substitution. The budget constraint of the representative household is given as

$$\sum_{i=a,m} p_{it} c_{it} \leq w_t, \tag{B.2}$$

where $p_{it}$ denotes sector's output prices and and $w$ is the total household income. The final output of each sector is determined as

$$Y_{it} = A_{it} L_{it}, \tag{B.3}$$

where $A_i$ is the sector-specific productivity and $L_i$ is the labour employment in sector $i$. All sectors produce final consumption good, hence $Y_{it} = c_{it}$ and the aggregate labour requirement $(L_t)$ satisfy the condition

$$L_{at} + L_{mt} = L_t$$

where $L_{it}$ is the labour employment in sector $i$ at time $t$. Without lost of generality and further assuming a CRS production technology, $L_t$ is normalized to 1 and $L_{it}$ interpreted as employment shares. The allocation of labour across sectors at any point in time satisfies the condition

$$VMPL_a = VMPL_m,$$

and from the firm's optimization problem yield

$$p_a A_a = p_m A_m.$$

Setting $P_m$ as the numeraire, the relative price of agricultural good is determined as

$$p_a = \frac{A_m}{A_a} \tag{B.4}$$

The first order conditions of the representative household utility maximization problem also yield

$$c_{at} = \left(\frac{\gamma_a}{\gamma_m}\right)^{\varepsilon} p_a^{-\varepsilon} c_{mt} + \bar{c}_a. \tag{B.5}$$

Given equations (B.4) and (B.5), and if all sectors produce final consumption good such that $c_{it} = Y_{it}$, the general equilibrium implications for labour allocation in agriculture at given time $t$ is determined as

$$L_a = \underbrace{\left(\frac{\gamma_a}{\gamma_m}\right)^{\varepsilon}\left(\frac{A_m}{A_a}\right)^{1-\varepsilon}}_{1} L_m + \underbrace{\frac{\bar{c_a}}{A_a}}_{2} \tag{B.6}$$

where $L_a$ and $L_m$ denote employment in agriculture and non-agriculture respectively; $\gamma_a$ and $\gamma_m$ are the expenditure shares for food and non-food; $A_a$ and $A_m$ are productivity in agriculture and non-agriculture; and $\bar{c_a}$ is the subsistence food requirement.

### The Effect of Productivity Growth in Agriculture on Labour Reallocation

Equation B.6 provides a general equilibrium framework to examine the implications of a rise in agricultural productivity through commercialization for labour reallocation. For example, given equation B.6

1. when $\varepsilon < 1$,

$$\text{if } A_a \uparrow, \left(\frac{A_m}{A_a}\right)^{1-\varepsilon} \downarrow \quad \text{and} \quad L_a \downarrow$$

2. also if income elasticity of demand for agricultural good is low, faster productivity growth in agriculture would also lead to labour reallocation away from the same. Thus,

$$\text{if } A_a \uparrow, \left(\frac{\bar{c_a}}{A_a}\right) \downarrow \quad \text{and} \quad L_a \downarrow$$

The model is calibrated to match initial conditions of sectoral employment in 2010 in the five SSA countries. The study calibrates the $\gamma_a$ and $\gamma_m$ to match the country-specific actual expenditure shares from national accounts. This data was obtained from the United Nations database. The study also calibrates $\varepsilon = 0.5$ (obtained from the literature) and $\bar{c_a} = 0.4172$. The value of $\bar{c_a}$ was taken from the calibration exercise in Chapter 2; this corresponds to about 90% of subsistence production in Ethiopia in 1970. Given $\gamma_i$, $\varepsilon$, and $\bar{c_a}$, productivity in non-agriculture $A_m$ in each country is set to 1 and the study determines the implied productivity in agriculture $A_{a,0}$ to match sectoral employment shares in 2010. Table B.6 reports the parameters for $\gamma_a$, $\gamma_m$, and $A_{a,0}$. Once all parameters are determined, I proceed to quantify the potential labour reallocation effect from a one-time increase in agricultural productivity due to the commercialization of purely subsistence farms. The productivity growth from commercialization is determined to be equivalent to the average TFP difference across subsistence and commercial farms. The estimates are reported in Tables 3.19 and 3.20 in section 3.5.2.

## B.4 Appendix Tables

Table B.1: Summary statistics on output, inputs, and farm productivity (Ethiopia)

| | | Farm Type | | Test of Significance |
|---|---|---|---|---|
| Category | All Farms | Subsistence | Commercial | Differences in Mean |
| Farm-Size (Hectare) | 0.19 | 0.16 | 0.39 | 0.23 *** |
| Labour per Farm (Man-Hours) | 29.94 | 27.23 | 50.22 | 22.99 *** |
| Land-labour Ratio | 0.01 | 0.01 | 0.02 | 0.00 |
| labour per Hectare | 2,153.11 | 2,377.96 | 469.72 | -1,908.25 * |
| | | | | |
| Market Value per Farm ($PPP) | 440.94 | 404.83 | 711.24 | 306.40 *** |
| Land Productivity ($ PPP) | 36,266.56 | 40,325.84 | 5,876.49 | -34,449.35 |
| labour Productivity ($ PPP) | 40.02 | 42.01 | 25.15 | -16.86 |
| | | | | |
| Quantity of Fertilizer per Farm (Kg) | 46.09 | 48.18 | 35.80 | -12.38 |
| Fertilizer per Hectare (Kg) | 2,103.29 | 2,491.75 | 195.52 | -2,296.24 |
| Cost of Chemical Input per Farm ($ PPP) | 115.14 | 109.35 | 143.34 | 33.99 *** |
| Cost of Chemical Input per Hectare ($ PPP) | 1,432.21 | 1,572.58 | 749.05 | -823.52 |

Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey year, 2013/2014.

Table B.2: Summary statistics on output, inputs, and farm productivity (Ghana)

| | | Farm Type | | Test of Significance |
|---|---|---|---|---|
| Category | All Farms | Subsistence | Commercial | Differences in Mean |
| Farm-Size (Hectare) | 1.43 | 1.09 | 1.61 | 0.52 *** |
| Labour per Farm (Man-Hours) | 137.97 | 98.36 | 158.47 | 60.11 |
| Land-labour Ratio | 0.03 | 0.02 | 0.04 | 0.02 *** |
| labour per Hectare | 155.06 | 179.18 | 142.58 | -36.60 *** |
| | | | | |
| Market Value per Farm ($PPP) | 1,130.06 | 395.70 | 1,510.25 | 1,114.55 *** |
| Land Productivity ($ PPP) | 1,019.31 | 503.97 | 1,286.11 | 782.14 *** |
| labour Productivity ($ PPP) | 21.00 | 6.86 | 28.32 | 21.46 *** |
| | | | | |
| Quantity of Fertilizer per Farm (Kg) | 150.44 | 258.13 | 96.43 | -161.70 *** |
| Fertilizer per Hectare (Kg) | 165.85 | 302.55 | 97.28 | -205.27 *** |
| Cost of Chemical Input per Farm ($ PPP) | 146.06 | 107.44 | 158.98 | 51.54 *** |
| Cost of Chemical Input per Hectare ($ PPP) | 140.80 | 113.57 | 149.91 | 36.34 |

Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey year, 2009/2010.

Table B.3: Summary statistics on output, inputs, and farm productivity (Malawi)

| | | Farm Type | | Test of Significance |
|---|---|---|---|---|
| Category | All Farms | Subsistence | Commercial | Differences in Mean |
| Farm-Size (Hectare) | 0.36 | 0.35 | 0.38 | 0.03 *** |
| Labour per Farm (Man-Hours) | 41.04 | 38.71 | 45.89 | 7.18 *** |
| Land-labour Ratio | 0.01 | 0.01 | 0.01 | -0.00 *** |
| labour per Hectare | 214.53 | 221.64 | 199.77 | -21.87 |
| | | | | |
| Market Value per Farm ($PPP) | 1,479.04 | 1,359.24 | 1,728.10 | 368.86 *** |
| Land Productivity ($ PPP) | 5,851.03 | 5,636.62 | 6,296.80 | 660.18 |
| labour Productivity ($ PPP) | 50.95 | 49.71 | 53.52 | 3.81 |
| | | | | |
| Quantity of Fertilizer per Farm (Kg) | 403.09 | 288.26 | 700.06 | 411.80 *** |
| Fertilizer per Hectare (Kg) | 2,613.51 | 2,682.01 | 2,436.37 | -245.64 |
| Cost of Chemical Input per Farm ($ PPP) | 263.93 | 237.35 | 326.45 | 89.10 *** |
| Cost of Chemical Input per Hectare ($ PPP) | 1,325.88 | 1,420.19 | 1,104.04 | -316.15 |

Note: This table report mean differences. Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey year, 2013.

Table B.4: Summary statistics on output, inputs, and farm productivity (Nigeria)

| | | Farm Type | | Test of Significance |
|---|---|---|---|---|
| Category | All Farms | Subsistence | Commercial | Differences in Mean |
| Farm-Size (Hectare) | 0.56 | 0.49 | 0.64 | 0.15 *** |
| Labour per Farm (Man-Hours) | 239.21 | 222.73 | 259.05 | 36.32 *** |
| Land-labour Ratio | 0.01 | 0.01 | 0.01 | -0.00 |
| labour per Hectare | 1,993.83 | 2,173.29 | 1,777.83 | -395.45 ** |
| | | | | |
| Market Value per Farm ($PPP) | 1,121.77 | 837.52 | 1,463.88 | 626.36 *** |
| Land Productivity ($ PPP) | 5,155.98 | 4,769.14 | 5,621.56 | 852.42 *** |
| labour Productivity ($ PPP) | 12.89 | 10.90 | 15.28 | 4.38 *** |
| | | | | |
| Quantity of Fertilizer per Farm (Kg) | 198.71 | 188.21 | 211.58 | 23.37 |
| Fertilizer per Hectare (Kg) | 801.38 | 881.75 | 702.89 | -178.86 ** |
| Cost of Chemical Input per Farm ($ PPP) | 155.90 | 130.47 | 183.17 | 52.70 *** |
| Cost of Chemical Input per Hectare ($ PPP) | 575.64 | 556.24 | 596.45 | 40.22 |

Note: This table report mean differences. Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey year, 2012/2013.

Table B.5: Summary statistics on output, inputs, and farm productivity (Tanzania)

| | | Farm Type | | Test of Significance |
|---|---|---|---|---|
| Category | All Farms | Subsistence | Commercial | Differences in Mean |
| Farm-Size (Hectare) | 1.28 | 0.91 | 1.82 | 0.91 *** |
| Labour per Farm (Man-Hours) | 80.12 | 65.63 | 101.40 | 35.77 *** |
| Land-labour Ratio | 0.02 | 0.02 | 0.02 | 0.00 ** |
| labour per Hectare | 162.45 | 173.88 | 145.64 | -28.24 *** |
| | | | | |
| Market Value per Farm ($PPP) | 693.17 | 373.44 | 1,163.07 | 789.63 *** |
| Land Productivity ($ PPP) | 1,030.29 | 848.17 | 1,297.94 | 449.77 *** |
| Labour Productivity ($ PPP) | 11.96 | 9.13 | 16.13 | 7.00 *** |
| | | | | |
| Quantity of Fertilizer per Farm (Kg) | 676.43 | 568.53 | 818.41 | 249.89 * |
| Fertilizer per Hectare (Kg) | 1,527.90 | 1,746.40 | 1,240.40 | -506.00 |
| Cost of Chemical Input per Farm ($ PPP) | 190.93 | 141.30 | 238.42 | 97.12 *** |
| Cost of Chemical Input per Hectare ($ PPP) | 52.82 | 42.87 | 67.44 | 24.58 *** |

Note: This table report mean differences. Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture. Survey year, 2012/2013.

Table B.6: Country-specific actual expenditure shares

| | Expenditure Shares | | Implied Productivity |
|---|---|---|---|
| Country | $\gamma_a$ | $\gamma_m$ | $A_{a,0}$ |
| Ethiopia | 0.45 | 0.55 | 1.43 |
| Ghana | 0.51 | 0.49 | 4.30 |
| Malawi | 0.50 | 0.50 | 1.67 |
| Nigeria | 0.59 | 0.41 | 2.55 |
| Tanzania | 0.57 | 0.43 | 1.43 |

Source: Expenditure share data are from the United Nations Database (UNData) National Accounts. Accessed May 26, 2016.

Table B.7: The relation between farm productivity and farm-size

| Dependent Variable: | Exclude Controls | | | | |
|---|---|---|---|---|---|
| Log Output per Labour | Ethiopia | Ghana | Malawi | Nigeria | Tanzania |
| Log Land (Ha) | 0.05 *** | 0.36 *** | 0.24 *** | 0.32 *** | 0.09 *** |
| | ( 0.007 ) | ( 0.029 ) | ( 0.022 ) | ( 0.022 ) | ( 0.015 ) |
| N | 20,232 | 4,711 | 6,035 | 4,948 | 5,236 |
| $\bar{R}^2$ | 0.01 | 0.05 | 0.03 | 0.07 | 0.01 |

| | Include Controls | | | | |
|---|---|---|---|---|---|
| Log Output per Labour | Ethiopia | Ghana | Malawi | Nigeria | Tanzania |
| Log Land (Ha) | 0.10 *** | 0.18 *** | 0.17 *** | 0.19 *** | 0.03 *** |
| | ( 0.009 ) | ( 0.028 ) | ( 0.023 ) | ( 0.025 ) | ( 0.016 ) |
| N | 17,987 | 4,675 | 5,236 | 4,580 | 5,214 |
| $\bar{R}^2$ | 0.09 | 0.24 | 0.13 | 0.16 | 0.12 |

Note: Include controls for geo-climatic conditions, credit constraint (land value) farm (irrigation, farm-tool type, tractor use, crop type), land (ecological zones, soil quality, land ownership, land topology); and household characteristics (age, sex, marital status and education of household head). Robust standard errors clustered at the household level are in parentheses. Asterisks denote significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

# Appendix C

# Determinants of Farm Commercialization in Sub-Saharan Africa: Evidence from Nigeria and Tanzania

## C.1 Appendix Tables

Table C.1: Inputs use, land, and labour productivity across subsistence and commercial farms

| | Nigeria | | | | Tanzania | | | |
|---|---|---|---|---|---|---|---|---|
| | 2012 | | | | 2012 | | | |
| Category | All | Subs | Comm | Ratio | All | Subs | Comm | Ratio |
| Land (Hectares) | 0.60 | 0.53 | 0.68 | 0.77 *** | 1.42 | 0.99 | 1.98 | 0.50 *** |
| Labour per Farm | 261.96 | 245.02 | 281.14 | 0.87 *** | 82.72 | 67.20 | 102.73 | 0.65 *** |
| Land-Labour Ratio | 0.01 | 0.01 | 0.01 | 1.52 | 0.02 | 0.02 | 0.03 | 0.69 ** |
| Labour per Hectare | 2,313.89 | 2,740.26 | 1,831.10 | 1.50 ** | 167.89 | 165.77 | 170.61 | 0.97 |
| Market Value per Farm ($ PPP) | 1,345.42 | 1,004.49 | 1,731.45 | 0.58 *** | 547.82 | 276.49 | 897.67 | 0.31 *** |
| Land Productivity ($ PPP) | 7,850.6 | 8,770.8 | 6,808.7 | 1.3 | 882.7 | 651.3 | 1,181.0 | 0.55 *** |
| Labour Productivity ($ PPP) | 13.78 | 11.94 | 15.87 | 0.75 *** | 9.10 | 6.23 | 12.80 | 0.49 *** |
| Fertilizer per Farm (Kg) | 225.08 | 213.03 | 237.97 | 0.90 | 495.51 | 466.77 | 532.23 | 0.88 |
| Fertilizer per Hectare (Kg/ha) | 847.74 | 906.23 | 785.19 | 1.15 | 1,185.63 | 1,461.50 | 833.28 | 1.75 |
| Cost of Chemical per Farm ($ PPP) | 177.86 | 141.88 | 213.73 | 0.66 *** | 147.92 | 83.87 | 210.57 | 0.40 *** |
| Cost of Chemical per Hectare ($ PPP) | 617.99 | 521.30 | 714.36 | 0.73 *** | 46.91 | 36.41 | 60.43 | 0.60 *** |

Note: Asterisks denote statistical significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

Table C.2: Correlates of commercialization in Nigeria - robustness analysis (panel)

| | Commercialization rate $\leq$ 20% | | Commercialization rate $\leq$ 40% | | Commercialization rate $\leq$ 60% | | Commercialization rate < 100% | |
|---|---|---|---|---|---|---|---|---|
| Variables | Coefficient | S.E | Coefficient | S.E | Coefficient | S.E | Coefficient | S.E |
| Labour | 0.05 *** | 0.01 | 0.05 *** | 0.02 | 0.03 * | 0.02 | 0.01 | 0.02 |
| Land | 0.14 *** | 0.02 | 0.13 *** | 0.02 | 0.15 *** | 0.02 | 0.14 *** | 0.03 |
| Chemical (fertilizer) | 0.05 *** | 0.01 | 0.05 *** | 0.01 | 0.04 *** | 0.01 | 0.02 | 0.02 |
| Land value | -0.00 | 0.01 | -0.02 | 0.02 | -0.01 | 0.02 | 0.04 | 0.02 |
| Rainfall | -0.00 | 0.00 | -0.00 ** | 0.00 | -0.00 | 0.00 | 0.00 | 0.00 |
| Agro-ecological zone (tropical warm=1) | 0.02 | 0.16 | -0.01 | 0.18 | 0.02 | 0.21 | -0.40 * | 0.24 |
| Crop type 1 (cereal=1) | -0.18 *** | 0.06 | -0.11 | 0.07 | -0.11 | 0.07 | 0.12 | 0.10 |
| Crop type 2 (vegetable=1) | 0.34 *** | 0.08 | 0.53 *** | 0.09 | 0.62 *** | 0.10 | 0.81 *** | 0.13 |
| Crop type 3 (fruit=1) | 1.27 *** | 0.26 | 1.31 *** | 0.24 | 1.24 *** | 0.24 | 1.42 *** | 0.25 |
| Crop type 4 (cash crop=1) | 0.98 *** | 0.26 | 1.24 *** | 0.25 | 1.37 *** | 0.24 | 1.65 *** | 0.25 |
| Soil quality 1 (nutrient availability, no constraint = 1) | -0.37 *** | 0.06 | -0.38 *** | 0.07 | -0.30 *** | 0.08 | -0.51 *** | 0.11 |
| Land topology (plain = 1) | 0.18 *** | 0.05 | 0.16 *** | 0.05 | 0.10 * | 0.06 | 0.11 | 0.08 |
| Land topology (mountain = 1) | 0.35 ** | 0.16 | 0.13 | 0.18 | 0.16 | 0.20 | 0.04 | 0.28 |
| Multi-cropping (yes = 1) | 0.05 | 0.05 | -0.15 *** | 0.05 | -0.15 ** | 0.06 | -0.34 *** | 0.08 |
| Irrigation (yes = 1) | 0.43 *** | 0.14 | 0.58 *** | 0.15 | 0.50 *** | 0.16 | 0.21 | 0.20 |
| Age of household head (years) | -0.01 *** | 0.00 | -0.01 *** | 0.00 | -0.01 *** | 0.00 | -0.01 *** | 0.00 |
| Gender of household head (male = 1) | 0.18 | 0.12 | 0.21 | 0.13 | 0.30 ** | 0.15 | 0.85 *** | 0.20 |
| Marital status of household head (married = 1) | -0.07 | 0.10 | -0.19 * | 0.11 | -0.15 | 0.12 | -0.47 *** | 0.14 |
| Education 1 (If head ever attended school = 1) | -0.05 | 0.05 | -0.04 | 0.05 | -0.01 | 0.06 | 0.03 | 0.08 |
| Education 2 (If head completed secondary = 1) | -0.06 | 0.06 | -0.08 | 0.07 | -0.15 * | 0.08 | -0.03 | 0.10 |
| Education 3 (If head completed tertiary = 1) | -0.25 *** | 0.09 | -0.13 | 0.10 | -0.14 | 0.11 | -0.07 | 0.14 |
| Household size | -0.00 ** | 0.00 | -0.00 ** | 0.00 | -0.01 *** | 0.00 | -0.01 * | 0.00 |
| Land ownership type (renting = 1) | -0.01 | 0.08 | 0.06 | 0.09 | 0.04 | 0.10 | -0.04 | 0.13 |
| Land ownership type (owned = 1) | -0.16 ** | 0.07 | -0.14 * | 0.07 | -0.26 *** | 0.08 | -0.33 *** | 0.10 |
| Distance to major road (kms) × 1000 | 3.22 ** | 1.45 | -0.66 | 1.65 | -1.48 | 1.90 | -1.08 | 2.53 |
| Distance to nearest market (kms) × 1000 | 1.09 * | 0.60 | 1.90 *** | 0.67 | 1.59 ** | 0.74 | -0.83 | 0.96 |
| Farm machinery use (yes = 1) | 0.06 | 0.05 | 0.13 ** | 0.06 | 0.24 *** | 0.06 | 0.15 * | 0.08 |
| Animal traction use (yes = 1) | -0.13 ** | 0.06 | -0.32 *** | 0.06 | -0.33 *** | 0.08 | -0.17 | 0.10 |
| Regional dummy (south = 1) | 0.94 *** | 0.08 | 1.12 *** | 0.09 | 1.10 *** | 0.10 | 1.20 *** | 0.13 |
| Year dummy (2012 = 1) | -0.10 ** | 0.04 | -0.08 | 0.05 | -0.11 * | 0.06 | -0.20 ** | 0.08 |
| Constant | -0.39 | 0.29 | -0.53 | 0.32 | -0.86 ** | 0.36 | -1.57 *** | 0.47 |
| N | 5,896 | | 5,896 | | 5,896 | | 5,896 | |

Note: Asterisks denote significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

Table C.3: Correlates of commercialization in Tanzania - robustness analysis (panel)

| | Commercialization rate ≤ 20% | | Commercialization rate ≤ 40% | | Commercialization rate ≤ 60% | | Commercialization rate < 100% | |
|---|---|---|---|---|---|---|---|---|
| Variables | Coefficient | S.E | Coefficient | S.E | Coefficient | S.E | Coefficient | S.E |
| Labour | 0.09 *** | 0.03 | 0.04 | 0.03 | -0.01 | 0.04 | -0.01 | 0.04 |
| Land | 0.20 *** | 0.03 | 0.17 *** | 0.03 | 0.12 *** | 0.03 | -0.01 | 0.04 |
| Chemical (fertilizer) | 0.03 ** | 0.01 | 0.02 | 0.01 | 0.04 *** | 0.01 | 0.03 ** | 0.02 |
| Land Value | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | -0.02 | 0.03 |
| Rainfall | -0.00 | 0.00 | -0.00 ** | 0.00 | -0.00 * | 0.00 | 0.00 | 0.00 |
| Agro-ecological zone (tropical warm=1) | 0.06 | 0.07 | 0.12 | 0.08 | 0.14 * | 0.08 | 0.05 | 0.09 |
| Crop type 1 (cereal=1) | -0.04 | 0.11 | -0.08 | 0.12 | -0.16 | 0.13 | -0.02 | 0.15 |
| Crop type 2 (vegetable=1) | 0.63 *** | 0.14 | 0.56 *** | 0.14 | 0.62 *** | 0.15 | 0.60 *** | 0.18 |
| Crop type 3 (fruit=1) | -0.03 | 0.18 | -0.32 | 0.20 | -0.40 * | 0.22 | -0.32 | 0.26 |
| Crop type 4 (cash crop=1) | 1.19 *** | 0.24 | 1.40 *** | 0.24 | 1.59 *** | 0.25 | 1.92 *** | 0.25 |
| Soil quality 1 (nutrient availability, no constraint = 1) | 0.26 ** | 0.11 | 0.18 | 0.11 | 0.17 | 0.12 | 0.17 | 0.14 |
| Soil quality 2 (nutrient retention capacity, no constraint = 1) | -0.66 *** | 0.20 | -0.71 *** | 0.22 | -0.66 *** | 0.23 | -0.45 * | 0.26 |
| Land topology (plain = 1) | -0.10 | 0.07 | -0.09 | 0.07 | -0.05 | 0.08 | -0.01 | 0.09 |
| Land topology (mountain = 1) | 0.01 | 0.11 | 0.00 | 0.11 | -0.05 | 0.12 | 0.01 | 0.14 |
| Multi-cropping (yes = 1) | 0.29 *** | 0.05 | 0.19 *** | 0.06 | 0.07 | 0.06 | 0.05 | 0.07 |
| Irrigation (yes = 1) | 0.93 *** | 0.20 | 0.92 *** | 0.20 | 0.86 *** | 0.20 | 0.82 *** | 0.22 |
| Age of household head (years) | -0.01 *** | 0.00 | -0.01 *** | 0.00 | -0.01 *** | 0.00 | -0.01 ** | 0.00 |
| Gender of household head (male = 1) | 0.00 | 0.10 | 0.08 | 0.11 | 0.14 | 0.12 | 0.04 | 0.13 |
| Marital status of household head (married = 1) | 0.01 | 0.10 | 0.07 | 0.11 | 0.08 | 0.11 | 0.26 * | 0.14 |
| Education 1 (If head ever attended school = 1) | 0.01 | 0.07 | 0.06 | 0.08 | 0.05 | 0.08 | -0.00 | 0.10 |
| Education 2 (If head completed secondary = 1) | -0.31 ** | 0.13 | -0.18 | 0.13 | -0.12 | 0.14 | -0.13 | 0.16 |
| Education 3 (If head completed tertiary = 1) | -0.53 | 0.45 | -0.77 | 0.53 | -0.81 | 0.62 | - | - |
| Land ownership type (renting = 1) | 0.17 | 0.21 | -0.17 | 0.23 | 0.09 | 0.24 | -0.07 | 0.29 |
| Land ownership type (owned = 1) | 0.34 *** | 0.11 | 0.28 ** | 0.12 | 0.29 ** | 0.13 | 0.31 ** | 0.15 |
| Distance to major road (kms) × 1000 | 0.15 | 1.62 | 1.27 | 1.69 | 0.18 | 1.79 | 1.53 | 2.07 |
| Distance to nearest market (kms) × 1000 | 0.13 | 0.67 | 0.45 | 0.70 | 0.79 | 0.73 | -0.04 | 0.84 |
| Regional dummy (east = 1) | -0.06 | 0.11 | -0.13 | 0.11 | -0.14 | 0.12 | -0.29 ** | 0.14 |
| Regional dummy (west = 1) | 0.26 ** | 0.10 | 0.38 *** | 0.11 | 0.34 *** | 0.11 | 0.15 | 0.13 |
| Year dummy (2010 = 1) | 0.19 *** | 0.06 | 0.15 ** | 0.06 | 0.20 *** | 0.06 | 0.28 *** | 0.08 |
| Year dummy (2012 = 1) | 0.13 ** | 0.06 | 0.09 | 0.06 | 0.18 *** | 0.07 | 0.32 *** | 0.08 |
| Constant | -1.09 *** | 0.38 | -1.45 *** | 0.40 | -1.47 *** | 0.42 | -1.94 *** | 0.49 |
| N | 4,753 | | 4,753 | | 4,753 | | 4,753 | |

Note: Asterisks denote significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

Table C.4: Correlates of transition in Nigeria - robustness analysis

| | Transitioning subsistence farms | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Commercialization rate ≤ 20% | | Commercialization rate ≤ 40% | | Commercialization rate ≤ 60% | | Commercialization rate < 100% | |
| Variables | Coefficient | S.E | Coefficient | S.E | Coefficient | S.E | Coefficient | S.E |
| Labour | 0.15 *** | 0.03 | 0.11 *** | 0.04 | 0.04 | 0.05 | 0.01 | 0.07 |
| Land | 0.09 ** | 0.04 | 0.09 ** | 0.04 | 0.15 *** | 0.05 | 0.06 | 0.08 |
| Chemical (fertilizer) | 0.05 *** | 0.02 | 0.06 *** | 0.02 | 0.04 | 0.03 | 0.02 | 0.04 |
| Land value | 0.05 | 0.03 | 0.05 | 0.04 | 0.07 | 0.05 | 0.11 | 0.07 |
| Rainfall | 0.00 | 0.00 | -0.00 | 0.00 | -0.00 | 0.00 | 0.00 | 0.00 |
| Agro-ecological zone (tropical warm=1) | -0.22 | 0.28 | -0.62 ** | 0.30 | -0.50 | 0.37 | -0.81 * | 0.42 |
| Crop type 1 (cereal=1) | -0.47 *** | 0.13 | -0.69 *** | 0.14 | -0.61 *** | 0.17 | -0.48 ** | 0.24 |
| Crop type 2 (vegetable=1) | -0.09 | 0.16 | -0.06 | 0.17 | 0.14 | 0.19 | 0.33 | 0.25 |
| Crop type 3 (fruit=1) | 1.32 ** | 0.55 | 0.91 * | 0.50 | 0.32 | 0.57 | - | - |
| Crop type 4 (cash crop=1) | 0.70 | 0.67 | 0.28 | 0.65 | 0.86 | 0.66 | 0.79 | 0.76 |
| Soil quality 1 (nutrient availability, no constraint = 1) | -0.33 *** | 0.12 | -0.34 ** | 0.13 | -0.40 ** | 0.16 | -0.36 | 0.25 |
| Land topology (plain = 1) | -0.03 | 0.09 | -0.11 | 0.10 | -0.22 * | 0.12 | -0.01 | 0.18 |
| Land topology (mountain = 1) | -0.08 | 0.40 | 0.29 | 0.41 | 0.42 | 0.45 | 0.63 | 0.61 |
| Multi-cropping (yes = 1) | 0.12 | 0.09 | -0.15 | 0.10 | -0.31 ** | 0.12 | -0.32 * | 0.18 |
| Irrigation (yes = 1) | 1.02 *** | 0.31 | 0.99 *** | 0.30 | 0.84 *** | 0.32 | 0.03 | 0.59 |
| Age of household head (years) | -0.00 | 0.00 | -0.01 *** | 0.00 | -0.01 ** | 0.00 | -0.01 * | 0.01 |
| Gender of household head (male = 1) | 0.18 | 0.22 | 0.07 | 0.23 | 0.21 | 0.28 | 0.43 | 0.57 |
| Marital status of household head (married = 1) | -0.11 | 0.18 | -0.24 | 0.19 | -0.27 | 0.23 | 0.28 | 0.45 |
| Education 1 (If head ever attended school = 1) | -0.06 | 0.09 | -0.11 | 0.10 | -0.11 | 0.12 | -0.33 * | 0.20 |
| Education 2 (If head completed secondary = 1) | -0.04 | 0.12 | -0.10 | 0.14 | -0.19 | 0.17 | 0.06 | 0.23 |
| Education 3 (If head completed tertiary = 1) | -0.32 * | 0.16 | -0.36 * | 0.19 | -0.34 | 0.23 | -0.49 | 0.43 |
| Household size | -0.00 | 0.00 | -0.00 | 0.00 | -0.01 ** | 0.00 | -0.01 * | 0.01 |
| Land ownership type (renting = 1) | -0.11 | 0.17 | -0.00 | 0.19 | -0.02 | 0.22 | -0.46 | 0.39 |
| Land ownership type (owned = 1) | -0.08 | 0.12 | -0.03 | 0.13 | -0.10 | 0.16 | -0.22 | 0.24 |
| Distance to major road (kms) × 1000 | 17.00 *** | 5.16 | 16.43 *** | 5.78 | 10.63 | 6.95 | 5.59 | 10.05 |
| Distance to nearest market (kms) × 1000 | 2.58 ** | 1.06 | 3.44 *** | 1.19 | 1.76 | 1.42 | 1.89 | 2.09 |
| Farm machinery use (yes = 1) | -0.11 | 0.11 | 0.01 | 0.12 | 0.17 | 0.14 | 0.22 | 0.20 |
| Animal traction use (yes = 1) | 0.12 | 0.10 | 0.09 | 0.12 | -0.00 | 0.15 | 0.05 | 0.23 |
| Regional dummy (south = 1) | 0.32 * | 0.17 | 0.59 *** | 0.19 | 0.71 *** | 0.22 | 0.22 | 0.31 |
| Constant | -1.65 | 0.64 | -0.72 | 0.71 | -0.83 | 0.87 | -1.89 | 1.28 |
| N | 1,394 | | 1,394 | | 1,394 | | 1,387 | |
| $R^2$ | 0.07 | | 0.10 | | 0.12 | | 0.15 | |

Note: Asterisks denote significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

Table C.5: Correlates of transition in Nigeria - robustness analysis

| | Transitioning commercial farms | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Commercialization rate ≤ 20% | | Commercialization rate ≤ 40% | | Commercialization rate ≤ 60% | | Commercialization rate < 100% | |
| Variables | Coefficient | S.E | Coefficient | S.E | Coefficient | S.E | Coefficient | S.E |
| Labour | -0.02 | 0.03 | -0.10 *** | 0.03 | -0.14 *** | 0.04 | -0.07 | 0.05 |
| Land | 0.16 *** | 0.04 | 0.12 *** | 0.04 | 0.18 *** | 0.04 | 0.11 ** | 0.05 |
| Chemical (fertilizer) | 0.07 *** | 0.02 | 0.09 *** | 0.02 | 0.08 *** | 0.02 | 0.03 | 0.03 |
| Land value | -0.08 *** | 0.03 | -0.09 *** | 0.03 | -0.10 *** | 0.03 | -0.03 | 0.04 |
| Rainfall | -0.00 | 0.00 | -0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Agro-ecological zone (tropical warm=1) | -0.39 | 0.28 | -0.47 | 0.29 | -0.03 | 0.34 | -0.23 | 0.40 |
| Crop type 1 (cereal=1) | -0.12 | 0.11 | -0.06 | 0.11 | -0.14 | 0.12 | 0.10 | 0.16 |
| Crop type 2 (vegetable=1) | 0.21 | 0.14 | 0.38 *** | 0.14 | 0.34 ** | 0.16 | 0.61 *** | 0.19 |
| Crop type 3 (fruit=1) | 0.61 | 0.74 | 0.88 | 0.74 | 1.22 | 0.75 | 2.06 *** | 0.73 |
| Crop type 4 (cash crop=1) | 0.49 | 0.54 | 0.60 | 0.54 | 0.59 | 0.53 | 1.21 ** | 0.55 |
| Soil quality 1 (nutrient availability, no constraint = 1) | -0.29 *** | 0.10 | -0.28 ** | 0.11 | -0.04 | 0.12 | -0.13 | 0.16 |
| Land topology (plain = 1) | 0.13 | 0.08 | 0.13 | 0.08 | 0.16 * | 0.09 | 0.12 | 0.12 |
| Land topology (mountain = 1) | 0.20 | 0.22 | 0.11 | 0.25 | 0.16 | 0.27 | 0.36 | 0.34 |
| Multi-cropping (yes = 1) | 0.06 | 0.08 | -0.15 * | 0.09 | -0.10 | 0.10 | -0.32 *** | 0.12 |
| Irrigation (yes = 1) | 0.28 | 0.29 | 0.12 | 0.30 | 0.16 | 0.33 | 0.24 | 0.38 |
| Age of household head (years) | -0.01 ** | 0.00 | -0.00 * | 0.00 | -0.01 ** | 0.00 | -0.00 | 0.00 |
| Gender of household head (male = 1) | -0.10 | 0.21 | 0.15 | 0.22 | 0.43 * | 0.24 | 0.63 ** | 0.31 |
| Marital status of household head (married = 1) | 0.30 * | 0.17 | 0.15 | 0.18 | -0.00 | 0.19 | -0.20 | 0.22 |
| Education 1 (If head ever attended school = 1) | -0.02 | 0.08 | -0.09 | 0.09 | -0.18 * | 0.10 | -0.04 | 0.13 |
| Education 2 (If head completed secondary = 1) | -0.39 *** | 0.11 | -0.36 *** | 0.12 | -0.30 ** | 0.14 | -0.03 | 0.17 |
| Education 3 (If head completed tertiary = 1) | -0.05 | 0.16 | -0.02 | 0.16 | 0.05 | 0.17 | 0.17 | 0.21 |
| Household size | -0.00 | 0.00 | -0.00 | 0.00 | -0.01 | 0.00 | -0.00 | 0.00 |
| Land ownership type (renting = 1) | 0.31 ** | 0.15 | 0.44 *** | 0.15 | 0.36 ** | 0.16 | 0.12 | 0.20 |
| Land ownership type (owned = 1) | -0.03 | 0.11 | -0.02 | 0.12 | -0.20 | 0.12 | -0.32 * | 0.16 |
| Distance to major road (kms) × 1000 | 1.28 | 4.44 | 3.13 | 4.79 | -5.91 | 5.42 | -6.66 | 7.12 |
| Distance to nearest market (kms) × 1000 | -0.29 | 0.97 | 1.69 * | 1.02 | 0.36 | 1.13 | -3.59 ** | 1.53 |
| Farm machinery use (yes = 1) | 0.10 | 0.09 | 0.16 * | 0.09 | 0.32 *** | 0.10 | 0.30 ** | 0.14 |
| Animal traction use (yes = 1) | -0.05 | 0.10 | -0.30 *** | 0.11 | -0.36 *** | 0.13 | -0.02 | 0.18 |
| Regional dummy (south = 1) | 0.92 *** | 0.12 | 1.09 *** | 0.13 | 0.99 *** | 0.14 | 0.85 *** | 0.17 |
| Constant | 1.27 | 0.57 | 1.25 | 0.61 | 1.08 | 0.68 | -0.42 | 0.85 |
| N | 1,457 | | 1,457 | | 1,457 | | 1,457 | |
| $R^2$ | 0.09 | | 0.13 | | 0.16 | | 0.15 | |

Note: Asterisks denote significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

Table C.6: Correlates of transition in Tanzania - robustness analysis

| | Transitioning subsistence farms | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Commercialization rate ≤ 20% | | Commercialization rate ≤ 40% | | Commercialization rate ≤ 60% | | Commercialization rate < 100% | |
| Variables | Coefficient | S.E | Coefficient | S.E | Coefficient | S.E | Coefficient | S.E |
| Labour | 0.00 | 0.06 | 0.01 | 0.06 | -0.03 | 0.07 | -0.04 | 0.08 |
| Land | 0.16 *** | 0.05 | 0.10 * | 0.05 | 0.09 | 0.06 | 0.02 | 0.07 |
| Chemical (fertilizer) | -0.02 | 0.02 | -0.03 | 0.02 | -0.00 | 0.03 | 0.00 | 0.03 |
| Land Value | -0.03 | 0.04 | 0.02 | 0.04 | -0.03 | 0.04 | -0.01 | 0.05 |
| Rainfall | -0.00 | 0.00 | -0.00 | 0.00 | -0.00 | 0.00 | -0.00 | 0.00 |
| Agro-ecological zone (tropical warm=1) | 0.10 | 0.11 | 0.18 | 0.12 | 0.35 ** | 0.14 | 0.29 * | 0.16 |
| Crop type 1 (cereal=1) | -0.06 | 0.20 | -0.21 | 0.22 | -0.45 * | 0.23 | -0.23 | 0.27 |
| Crop type 2 (vegetable=1) | 0.60 ** | 0.25 | 0.51 * | 0.27 | 0.43 | 0.28 | 0.55 * | 0.32 |
| Crop type 3 (fruit=1) | - | - | - | - | - | - | - | - |
| Crop type 4 (cash crop=1) | 1.21 * | 0.64 | 1.35 ** | 0.65 | 1.40 ** | 0.65 | 1.64 ** | 0.68 |
| Soil quality 1 (nutrient availability, no constraint = 1) | 0.18 | 0.16 | 0.07 | 0.18 | -0.21 | 0.21 | -0.05 | 0.23 |
| Soil quality 2 (nutrient retention capacity, no constraint = 1) | -0.33 | 0.27 | -0.72 ** | 0.35 | -0.86 * | 0.50 | -0.73 | 0.53 |
| Land topology (plain = 1) | 0.05 | 0.11 | 0.05 | 0.12 | 0.06 | 0.13 | 0.11 | 0.15 |
| Land topology (mountain = 1) | 0.09 | 0.16 | 0.06 | 0.18 | -0.14 | 0.21 | 0.03 | 0.24 |
| Multi-cropping (yes = 1) | 0.23 ** | 0.10 | 0.14 | 0.11 | 0.07 | 0.12 | -0.09 | 0.14 |
| Irrigation (yes = 1) | 0.91 ** | 0.44 | 1.13 ** | 0.45 | 0.99 ** | 0.45 | 0.18 | 0.61 |
| Age of household head (years) | -0.01 ** | 0.00 | -0.01 ** | 0.00 | -0.00 | 0.00 | 0.00 | 0.00 |
| Gender of household head (male = 1) | -0.14 | 0.16 | -0.12 | 0.18 | -0.06 | 0.20 | -0.09 | 0.23 |
| Marital status of household head (married = 1) | 0.25 | 0.17 | 0.30 * | 0.18 | 0.36 * | 0.20 | 0.59 ** | 0.25 |
| Education 1 (If head ever attended school = 1) | -0.13 | 0.12 | -0.07 | 0.13 | -0.09 | 0.14 | -0.26 | 0.16 |
| Education 2 (If head completed secondary = 1) | -0.38 * | 0.21 | -0.20 | 0.22 | -0.14 | 0.24 | 0.09 | 0.26 |
| Education 3 (If head completed tertiary = 1) | 0.13 | 0.66 | 0.40 | 0.67 | - | - | - | - |
| Land ownership type (renting = 1) | 0.67 ** | 0.33 | -0.42 | 0.53 | -0.19 | 0.53 | 0.35 | 0.57 |
| Land ownership type (owned = 1) | 0.48 ** | 0.20 | 0.54 ** | 0.23 | 0.44 * | 0.25 | 0.64 * | 0.34 |
| Distance to major road (kms) × 1000 | 2.72 | 2.35 | 4.36 * | 2.54 | 3.94 | 2.84 | 6.72 ** | 3.33 |
| Distance to nearest market (kms) × 1000 | 0.05 | 1.02 | 0.32 | 1.11 | 0.93 | 1.23 | 0.14 | 1.45 |
| Regional dummy (east = 1) | 0.01 | 0.17 | -0.04 | 0.18 | 0.06 | 0.20 | -0.05 | 0.24 |
| Regional dummy (west = 1) | 0.17 | 0.17 | 0.28 | 0.18 | 0.34 * | 0.20 | 0.37 | 0.24 |
| Constant | -0.56 | 0.67 | -1.54 ** | 0.73 | -1.31 * | 0.79 | -2.39 | 0.95 |
| N | 962 | | 962 | | 957 | | 957 | |
| $R^2$ | 0.08 | | 0.09 | | 0.10 | | 0.11 | |

Note: Asterisks denote significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%.
Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.

Table C.7: Correlates of transition in Tanzania - robustness analysis

| | Transitioning commercial farms | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Commercialization rate ≤ 20% | | Commercialization rate ≤ 40% | | Commercialization rate ≤ 60% | | Commercialization rate < 100% | |
| Variables | Coefficient | S.E | Coefficient | S.E | Coefficient | S.E | Coefficient | S.E |
| Labour | 0.06 | 0.06 | -0.03 | 0.06 | -0.03 | 0.07 | -0.05 | 0.07 |
| Land | 0.02 | 0.05 | 0.00 | 0.05 | -0.03 | 0.06 | -0.07 | 0.06 |
| Chemical (fertilizer) | 0.02 | 0.02 | 0.02 | 0.02 | 0.04 | 0.02 | 0.05 ** | 0.03 |
| Land Value | 0.02 | 0.04 | 0.06 | 0.04 | -0.01 | 0.05 | -0.02 | 0.05 |
| Rainfall | -0.00 | 0.00 | -0.00 | 0.00 | -0.00 | 0.00 | 0.00 | 0.00 |
| Agro-ecological zone (tropical warm=1) | -0.13 | 0.12 | -0.03 | 0.12 | 0.01 | 0.12 | -0.04 | 0.14 |
| Crop type 1 (cereal=1) | 0.33 | 0.28 | 0.57 * | 0.29 | 0.31 | 0.29 | 0.63 * | 0.36 |
| Crop type 2 (vegetable=1) | 0.68 ** | 0.33 | 0.98 *** | 0.34 | 1.00 *** | 0.34 | 1.27 *** | 0.40 |
| Crop type 3 (fruit=1) | - | - | - | - | - | - | - | - |
| Crop type 4 (cash crop=1) | 0.79 * | 0.46 | 1.31 *** | 0.47 | 1.16 ** | 0.46 | 1.82 *** | 0.51 |
| Soil quality 1 (nutrient availability, no constraint = 1) | 0.05 | 0.16 | 0.06 | 0.16 | 0.06 | 0.17 | 0.07 | 0.18 |
| Soil quality 2 (nutrient retention capacity, no constraint = 1) | 0.67 | 0.42 | 0.44 | 0.40 | 0.59 | 0.40 | 0.34 | 0.43 |
| Land topology (plain = 1) | 0.00 | 0.11 | -0.00 | 0.11 | 0.08 | 0.12 | 0.14 | 0.13 |
| Land topology (mountain = 1) | 0.04 | 0.19 | -0.07 | 0.19 | 0.05 | 0.19 | 0.23 | 0.21 |
| Multi-cropping (yes = 1) | 0.09 | 0.11 | 0.02 | 0.11 | -0.06 | 0.11 | -0.18 | 0.12 |
| Irrigation (yes = 1) | 0.66 * | 0.36 | 0.70 ** | 0.35 | 0.58 * | 0.33 | 0.06 | 0.37 |
| Age of household head (years) | -0.00 | 0.00 | -0.00 | 0.00 | -0.00 | 0.00 | 0.00 | 0.00 |
| Gender of household head (male = 1) | -0.04 | 0.19 | 0.20 | 0.19 | 0.23 | 0.20 | 0.34 | 0.23 |
| Marital status of household head (married = 1) | -0.01 | 0.19 | -0.05 | 0.19 | 0.10 | 0.20 | 0.03 | 0.22 |
| Education 1 (If head ever attended school = 1) | 0.18 | 0.14 | 0.11 | 0.14 | 0.19 | 0.15 | 0.21 | 0.16 |
| Education 2 (If head completed secondary = 1) | -0.44 ** | 0.22 | -0.34 | 0.22 | -0.16 | 0.22 | -0.28 | 0.25 |
| Education 3 (If head completed tertiary = 1) | - | - | - | - | - | - | - | - |
| Land ownership type (renting = 1) | 0.64 | 0.79 | 0.06 | 0.79 | 0.37 | 0.80 | 0.90 | 0.82 |
| Land ownership type (owned = 1) | 0.34 | 0.22 | 0.28 | 0.23 | 0.34 | 0.24 | 0.40 | 0.29 |
| Distance to major road (kms) × 1000 | -0.06 | 2.66 | -0.01 | 2.70 | -2.65 | 2.83 | 0.19 | 3.12 |
| Distance to nearest market (kms) × 1000 | -1.07 | 1.03 | -1.25 | 1.05 | -0.22 | 1.07 | -0.74 | 1.19 |
| Regional dummy (east = 1) | 0.11 | 0.17 | -0.01 | 0.17 | 0.01 | 0.18 | -0.20 | 0.20 |
| Regional dummy (west = 1) | 0.21 | 0.17 | 0.15 | 0.17 | 0.16 | 0.18 | -0.06 | 0.20 |
| Constant | -1.11 | 0.79 | -1.80 ** | 0.80 | -1.32 | 0.82 | -1.95 | 0.93 |
| N | 647 | | 647 | | 647 | | 647 | |
| $R^2$ | 0.04 | | 0.04 | | 0.06 | | 0.08 | |

Note: Asterisks denote significance: *Significant at 10%; **Significant at 5%; ***Significant at 1%. Source: The Living Standard Measurement Survey - Integrated Surveys on Agriculture.