

Crop Choice and Infrastructure Accessibility in Tanzania

Subsistence Crops or Export Crops?

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Abstract

Africa has great potential for agriculture. Although international commodity prices have been buoyant, Africa's supply response seems to be weak. A variety of constraints may exist. Using the case of Tanzania, the paper examines the impact of market connectivity, domestic and international, on farmers' crop choices. It is shown that the international market connectivity, measured by transport costs to the maritime port, is important for farmers to choose export crops, such as cotton and tobacco. Internal connectivity

to the domestic market is also found to be important for growing food crops, such as maize and rice. Among other inputs, access to irrigation and improved seed availability are also important factors in the crop choices of farmers. The size of land area is one constraint to promote the crop shift. The paper also reports the finding that farmers are not using market prices effectively in their choice of crop, even after the endogeneity of local prices is taken into account.

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**CROP CHOICE AND INFRASTRUCTURE ACCESSIBILITY IN TANZANIA
SUBSISTENCE CROPS OR EXPORT CROPS?**

June 2015

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JEL classification: H54; H41; Q12; C24.

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I. INTRODUCTION

Africa is abundant in natural resources and has great potential for agriculture. Agriculture and agribusiness currently generate nearly half the GDP of the region, or \$313 billion of commodities and products every year. This is projected to increase to \$1 trillion by 2030 (World Bank 2013). However, significant potential remains to be developed. Africa's agriculture is still mostly small-scale subsistence farming, and the current yields are far below potential levels (e.g., World Bank 2012).

Despite recent fluctuations, international commodity prices driven up by strong global demand for food are still favorable to many African countries. For instance, Africa's coffee and groundnuts prices nearly doubled in the 2000s (Figure 1). Tea and cotton prices also increased by 30-40 percent (World Bank 2013). In the last five years, coffee exports from East Africa nearly doubled in value terms (Figure 2). However, this is largely explained by the high commodity prices, not export quantities (Figure 3). Trade statistics show no clear evidence of a sharp supply response in Africa. As a result, Africa's presence in the global food market has been declining over the last decades.¹

Farmers' shift toward cash and export crops seems to be particularly slow in Africa. A variety of constraints have been discussed in the literature. In Africa, for instance, farmers have little access to quality inputs and new technology. Irrigation and fertilizer are critical inputs for agriculture (e.g., Gyimah-Brempong, 1987; Bravo-Ortega and Lederman, 2004), often found to be lacking. In Zambia, timely fertilizer supply increased maize yields by 11 percent on average (Xu et al., 2009). Irrigation availability nearly doubled agricultural productivity in Mali (Dillon, 2011). In general, however, access to agricultural inputs in Africa is problematic for many agricultural producers.

¹ Africa's share of global agricultural exports declined from 7 percent in the 1970s to 2 percent in 2009 (World Bank 2013).

Public infrastructure is also limited in scope and quality. Rural accessibility measured by the proportion of the rural residents within a 2-km walking distance from an all-weather road is less than 30 percent in Africa (Gwilliam 2011). This adds to farmers' production costs, particularly in rural and remote areas where poverty is highest. Lack of transport infrastructure or high transport costs increase input prices and reduce the marketability of products. Since transport costs are high in Africa, farmers have to pay 30 percent more for fertilizer on average, which is mostly imported from abroad, than in other agriculture-based countries, such as Thailand. In Uganda, transport costs account for more than 20 percent of the total fertilizer cost (World Bank 2013).

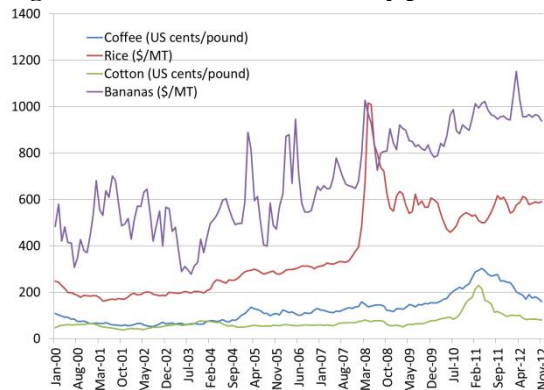
A growing literature also suggests that access to information and communications technology (ICT) is another important factor to transform agriculture production. In Uganda, access to market information has been found to have a positive impact on the adoption of new seed types and farmers' revenue (Kiiza and Pederson, 2012). In Ghana, information on market prices received on mobile phones stimulated greater participation of farmers in markets (Zanello 2012). But it is only very recently that Africa started catching up with the global ICT evolution.

The farmers' crop choice is a complex process, affected by technological constraints as well as financial incentives. Moreno and Sunding (2005) show that in California, the adoption of irrigation technology is determined not only by environmental conditions, such as surface water availability and soil permeability, but also water prices. In Uganda, households' selection of commercial varieties of bananas was found to decrease with distance from the market (Edmeades et al., 2008). In addition, crop choice can also be sensitive to climate conditions. For instance, Kurukulasuriya and Mendelsohn (2007) examined data from 11 African countries and found crop choice to be dependent on temperature and precipitation.

This paper examines farmers' crop choice in Tanzania, focusing particularly on the selection between domestic food and export crops. For obvious reasons, crop suitability, such as soil and weather conditions, matters and is therefore included in the analysis. But more attention

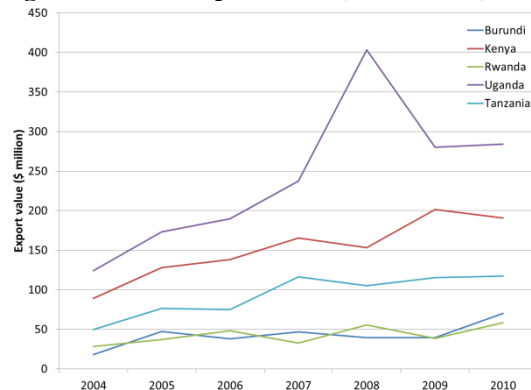
is paid to the effects of infrastructure accessibility, such as transport connectivity to markets. Other agriculture inputs, such as fertilizer and irrigation, are also taken into account. Using the conventional logit framework, the paper identifies the key determinants of the choice of export crops. The remaining sections are organized as follows: Section II provides a brief overview of the agriculture sector in Tanzania. Section III and IV discuss our methodology and data, respectively. Section V discusses main results and some policy implications. And Section VI concludes.

Figure 1. International commodity prices



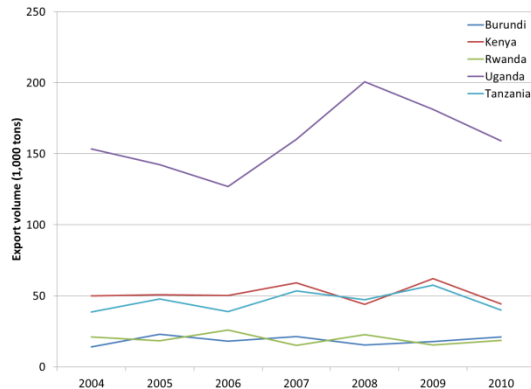
Source: IMF.

Figure 2. Coffee export value (US\$ million)



Source: FAOSTAT.

Figure 3. Coffee export volume (1,000 tons)



Source: FAOSTAT.

II. AGRICULTURE IN TANZANIA

Tanzania is traditionally heavily dependent on agriculture. Although its contribution to the economy has been declining due to other emerging industries, such as mining, the agriculture sector still employs about 75 percent of the workforce and produces about one-fourth of GDP (Ministry of Agriculture Food Security and Cooperatives, 2008). In Tanzania, about 95 percent of total food consumption is met by domestic supply. Particularly in rural areas, the vast majority of people depend on subsistence agriculture for their livelihood, with rural poverty endemic. The poverty ratio of Tanzania was estimated at 33 percent in 2007. Therefore, agricultural development continues to be one of the most important development issues in the country.

Agriculture productivity in Tanzania has been improving but continues to compare unfavorably with other African countries. According to FAO statistics, Tanzania's yields are below African averages for many major crops (Figure 4). Food crop production is dominated by small-scale subsistence farming with little modern technology adopted. Even for traditional export crops, such as cotton, coffee, cashew nuts and tea (Figure 5), there appears to be considerable potential for productivity improvement.

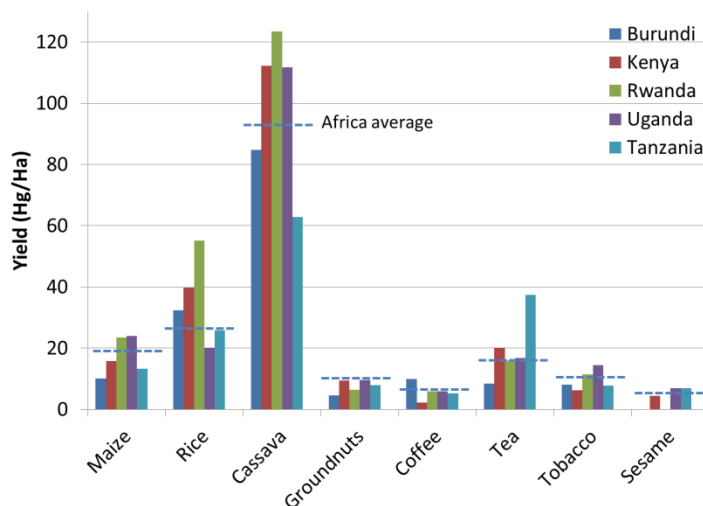
The Government of Tanzania has been making significant efforts toward modernizing the sector and increasing agriculture production by supporting irrigation and mechanization and providing agricultural research and training services. Agricultural exports are among the important foreign exchange earners and identified as one of the most important priority sectors to strengthen.² Agricultural exports account for about 15 percent of the total exports. Agriculture also has the potential for import substitution and food self-sufficiency. The country imports US\$750 million of agricultural products, such as wheat, palm oil and rice,

² "Tanzania: Five Year Development Framework, 2011/12-2015/16." Ministry of Agriculture Food Security and Cooperatives, Tanzania.

every year (Figure 6). Not only Tanzania but also other East African countries are large food importers and running the significant current account deficits (Figure 7).³

Despite the recent buoyancy in international commodity prices, the farmers' supply response does not seem to be strong in Tanzania. According to the Agriculture Sample Census 2007/08, only 7 percent of the total land was cultivated for cash crops, although the share marginally increased from 5 percent in 2002/03. About two-thirds of land is used to grow cereals, mainly maize, and rice and sorghum to a lesser extent (Figure 8).

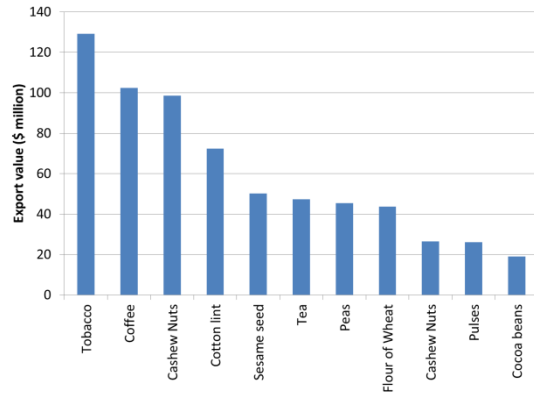
Figure 4. Yields by crop, 2011



Source: FAOSTAT.

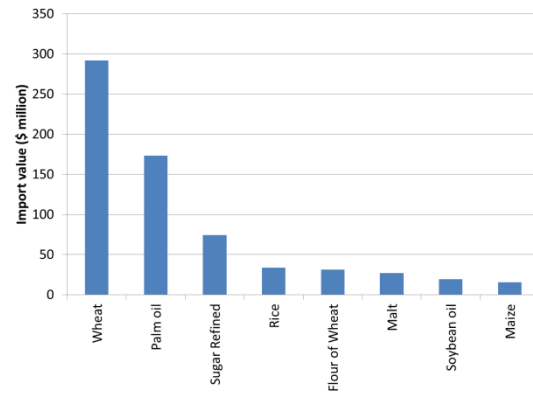
³ East African countries currently have about 5 to 15 percent of current account deficits. As the regional economy is growing rapidly, the deficits have been widening in recent years. In total, East Africa imports about \$30 billion of food (e.g., such as oil palm and rice) every year.

Figure 5. Tanzania: Agricultural exports, 2011



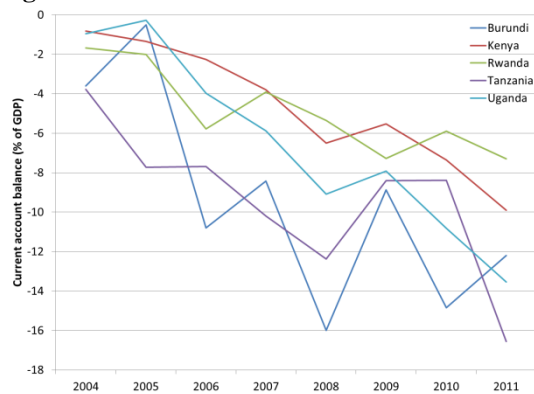
Source: FAOSTAT.

Figure 6. Tanzania: Agricultural imports, 2011



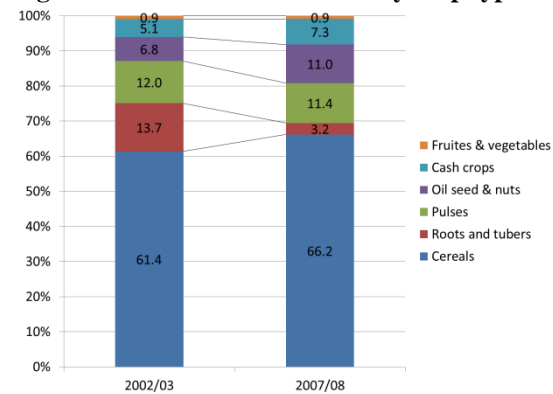
Source: FAOSTAT.

Figure 7. Current account balance



Source: WDI and IMF.

Figure 8. Tanzania: Land areas by crop type



Source: Tanzania Agriculture Sample Census.

Various constraints exist and may inhibit farmers from exploiting the opportunity to grow cash and export crops.⁴ Many farmers are still not well connected to the markets—domestic or global. In Tanzania, rural accessibility is estimated at 24 percent (Figure 9).⁵ In addition, global markets—both input and output—are distant from farmers who live in hinterland areas. For instance, the transport costs from a major inland agricultural production area, around Kigoma on Lake Tanganyika, to the port of Dar es Salaam is estimated at US\$177 per

⁴ These are not new constraints but have long been discussed in the country. For instance, Baffes (2002) discusses institutional and physical constraints to boost cotton exports. The pointed constraints, such as complexity in customs procedures, deterioration of railroad services and unavailability of improve seeds, are still among the current major constraints.

⁵ Rural accessibility, defined by the proportion of the rural population within a 2-km walking distance of an all-season road, is estimated at only 20-30 percent in the region (Gwilliam et al. 2011).

ton (Figure 10).⁶ The time costs of delayed shipments from waiting at stations, border points and ports are crucial inhibitors to success in the international high-value crop market, as evidenced by Kenya's horticultural sector.

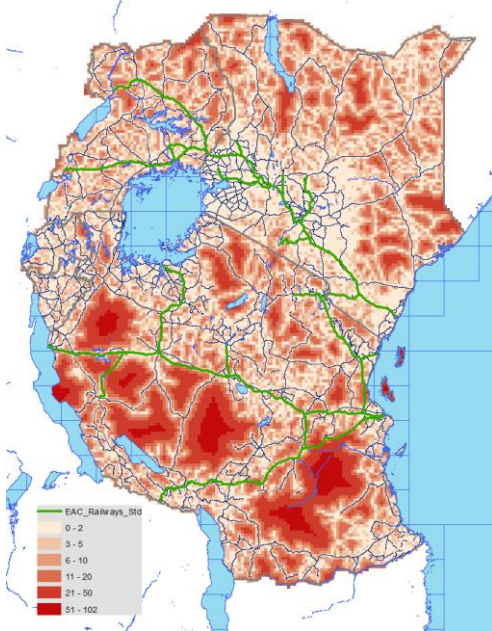
Fertilizer use remains minimal in Tanzania, despite some successes, such as the government's fertilizer subsidies improving productivity of some food crops, such as maize and rice, in the early 2000s, fertilizer use remains sparse in Tanzania. In addition, even where used fertilizer intensity remains low in Tanzania (Ministry of Agriculture Food Security and Cooperatives, 2008). The recent success of a neighboring country, Rwanda, indicates that agriculture productivity can be improved dramatically by the commercialization of the sector: Fertilizer use more than doubled from 18 percent to 38 percent over the last five years (2007-2012).⁷

Water resources are available in many parts of Tanzania, but the benefits of irrigation have not yet been exploited. Only 1 percent of land considered suitable for irrigation is currently irrigated (Figure 13). Tanzania has 29.4 million ha of land considered to be suitable for irrigation, out of which 2.3 million ha are considered to have high development potential. However, only 289,000 ha of land were irrigated as of 2009 (Ministry of Agriculture Food Security and Cooperatives, 2008).

⁶ By international comparison, Tanzania's export and import costs are relatively favorably compared with its neighboring countries (Figures 11 and 12). However, given the size of the country taken into account, the transport and trade conditions of the inland areas of Tanzania may be close to those of the regional landlocked countries, such as Burundi and Rwanda.

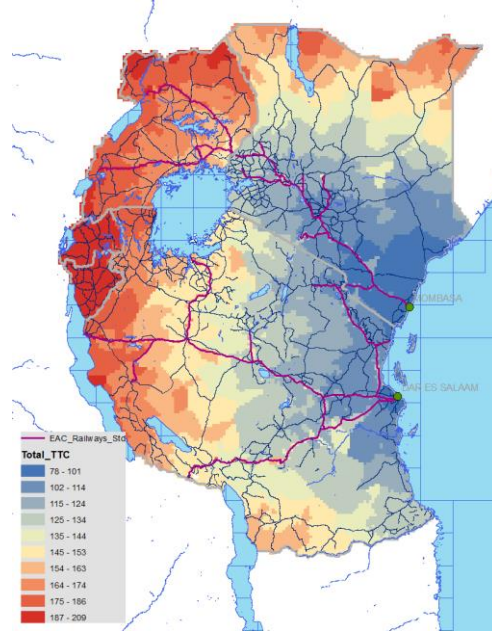
⁷ "Rwanda: Fourth review under the policy support instrument and request for modification of assessment criteria" 2012. IMF.

Figure 9. Rural Accessibility (km to a road)



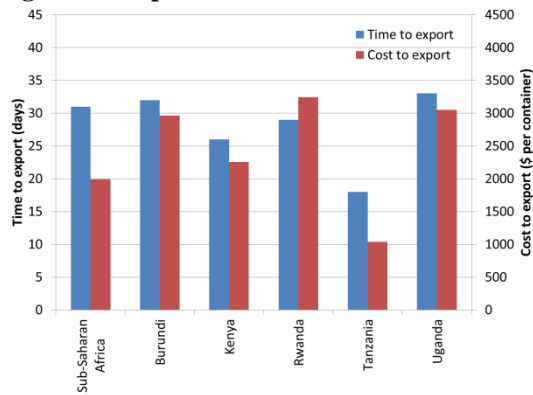
Source: World Bank calculations.

Figure 10. Transport costs to the port



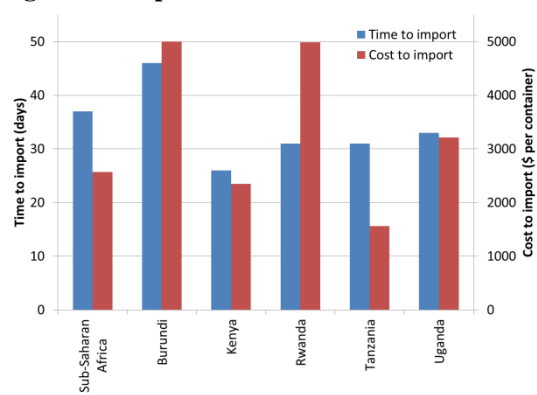
Source: World Bank calculations.

Figure 11. Export costs and time



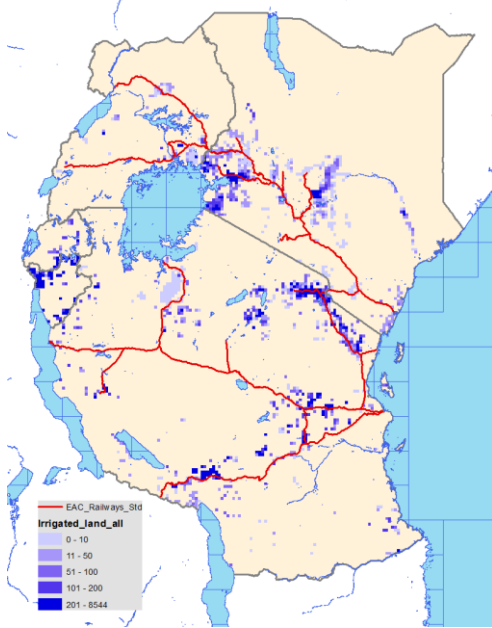
Source: Doing Business 2013.

Figure 12. Import costs and time



Source: Doing Business 2013.

Figure 13. Irrigated agriculture production areas (ha)



Source: SPAM Update 2010.

III. EMPIRICAL MODEL

To examine farmers' crop choice in Tanzania, the traditional random utility maximization framework is considered (e.g., McFadden, 1974; Maddala, 1983). Suppose that household(-plot) i chooses crop j among alternatives $j = 1, \dots, J$, and the household's utility U_{ij} is assumed to be composed of two part: deterministic component V_{ij} and stochastic error ε_{ij} .⁸

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad (1)$$

The deterministic part of the utility is affected by both alternative-specific conditions X , such as crop suitability of land and local crop prices, and individual-specific characteristics Z , such as gender and educational attainment of the household head.

⁸ Technically speaking, our unit of analysis is a plot. However, many households have only one plot. If a household owns more than one plot, they are treated as different observations.

$$V_{ij} = X' \beta + Z' \gamma \quad (2)$$

Under the conventional McFadden's (1974) conditional logit specification, the probability of household i choosing crop j is written by:

$$\begin{aligned} \Pr(y_i = j) &= \Pr(U_{ij} > U_{ik}) \quad \text{for } \forall k \neq j \\ &= \exp(X_{ij}' \beta + Z_i' \gamma_j) / \sum_j \exp(X_{ij}' \beta + Z_i' \gamma_j) \end{aligned} \quad (3)$$

Note that individual-specific characteristics Z do not vary across choices. Using the choice-specific dummy variables, the individual-specific effects are differentiated across choices (e.g., Greene 1997; Procher, 2011).

One of the major disadvantages of the conditional logit approach is that the preferences of the respondents are assumed to be the same. Another disadvantage is the property referred to as independence of irrelevant alternatives (IIA), which requires that preferences between any pair of two choices are independent of the third option. In our context, it means that the odds ratio of producing a crop, for instance, maize to another crop, for instance, tobacco is the same irrespective of other crop alternatives, such as rice. But the IIA assumption does not seem to hold in the crop choice context, because maize is perhaps substitutable to rice to a certain extent, but not to tobacco (e.g., Moreno and Sunding, 2005)

This problem can partly be overcome by the nested logit model, in which all alternatives $j = 1, \dots, J$ are exclusively partitioned into K subgroups $\{G_1, \dots, G_K\}$ and the IIA assumption is relaxed across the nests G 's (e.g., Maddala, 1983; McFadden, 1984). Substitution patterns are still restricted within each nest, but the relative attractiveness of the two alternatives in different nests can vary depending on the attributes of other alternatives in the two nests. As usual, the joint probability of household i 's choosing crop j in nest G_k is written by (i) the conditional probability of choosing crop j given that an alternative in nest G_k is chosen, and (ii) the marginal probability of choosing an alternative in nest G_k :

$$\begin{aligned} \Pr(y_i = j) &= \Pr(y_i = j | G_k) \times \Pr(y_i = k) \\ &= \left[\exp(X_{ij}'\beta / \tau_j) / \exp(IV_j) \right] \times \left[\exp(Z_i'\gamma_j / \tau_j + IV_j) / \sum_k \exp(Z_k'\gamma_j / \tau_j + IV_j) \right] \end{aligned} \quad (4)$$

where the dissimilarity parameter to adjust the scaling across subgroups is defined by

$\tau_k = \sqrt{1 - \rho_k}$. ρ is correlation within nest k . The inclusive value is defined by

$$IV_j = \ln \sum_{j \in G_k} \exp(X_{ij}'\beta / \tau_k).$$

In the following analysis, seven crop choices classified into two subgroups, domestic food crop and export crop, are examined: maize, rice, cassava, groundnuts, tobacco, cotton and sesame. The selection reflects the significance of these products in Tanzania as well as data availability in the household survey used. The geographic distribution of the current and potential production areas is also taken into account. The first four crops are among the largest agricultural commodities produced in Tanzania (Figure 14). These crops account for about 30 percent of the total agriculture production in value terms.

The last three crops are among the major export crops, accounting for about 35 percent of the total agriculture exports from Tanzania (Figure 4 above). Tobacco is the largest export crop, and its production more than doubled from 50,000 tons in 2005 to 130,000 tons in 2011 (Figure 15). Sesame is also a growing export crop in the southern region of Tanzania. Cotton is one of the most traditional export crops in the country, dating from the early 1900s.⁹

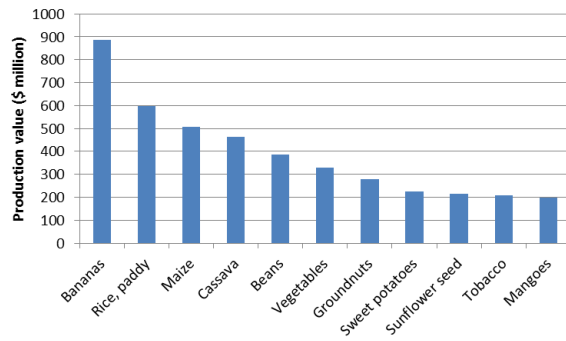
Several major crops are excluded from the analysis, mainly because of the lack of sufficient data. Bananas and two important export crops, coffee and tea, are excluded, because our primary data source of the analysis, which is the 2010 Living Standards Measurement Study (LSMS), does not include many households producing these crops.

⁹ See for instance Baffes (2002).

From the agro-ecological point of view, our choice set comprising the seven crops is mostly applicable to the places where the household survey was carried out. As shown in Figure 16, most of the seven crops can potentially be grown in the places where the household survey was carried out. Sesame may be something of a limited choice for some farmers for agro-ecological reasons. But farmers chose a particular crop for one reason or another. Our model will control for crop suitability.

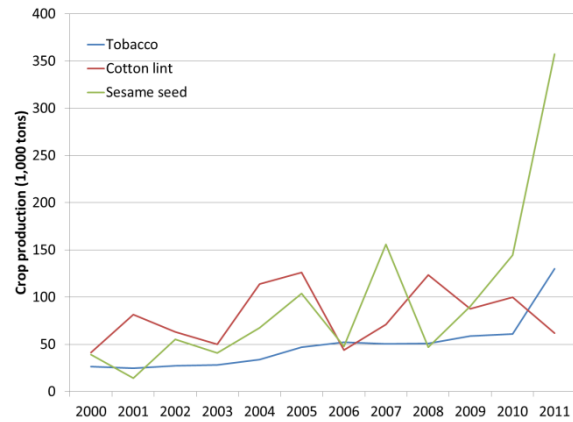
The analysis focuses on the difference between domestic food crops and export commodities. Thus, we have only two nests, $k = \{D, E\}$ where D and E stand for domestic and export crops, respectively. This nesting structure allows an examination of whether crop choice behavior is different between domestic and export crops in response to alternative-specific conditions, such as crop prices and infrastructure availability.

Figure 14. Tanzania: Agriculture production, 2011



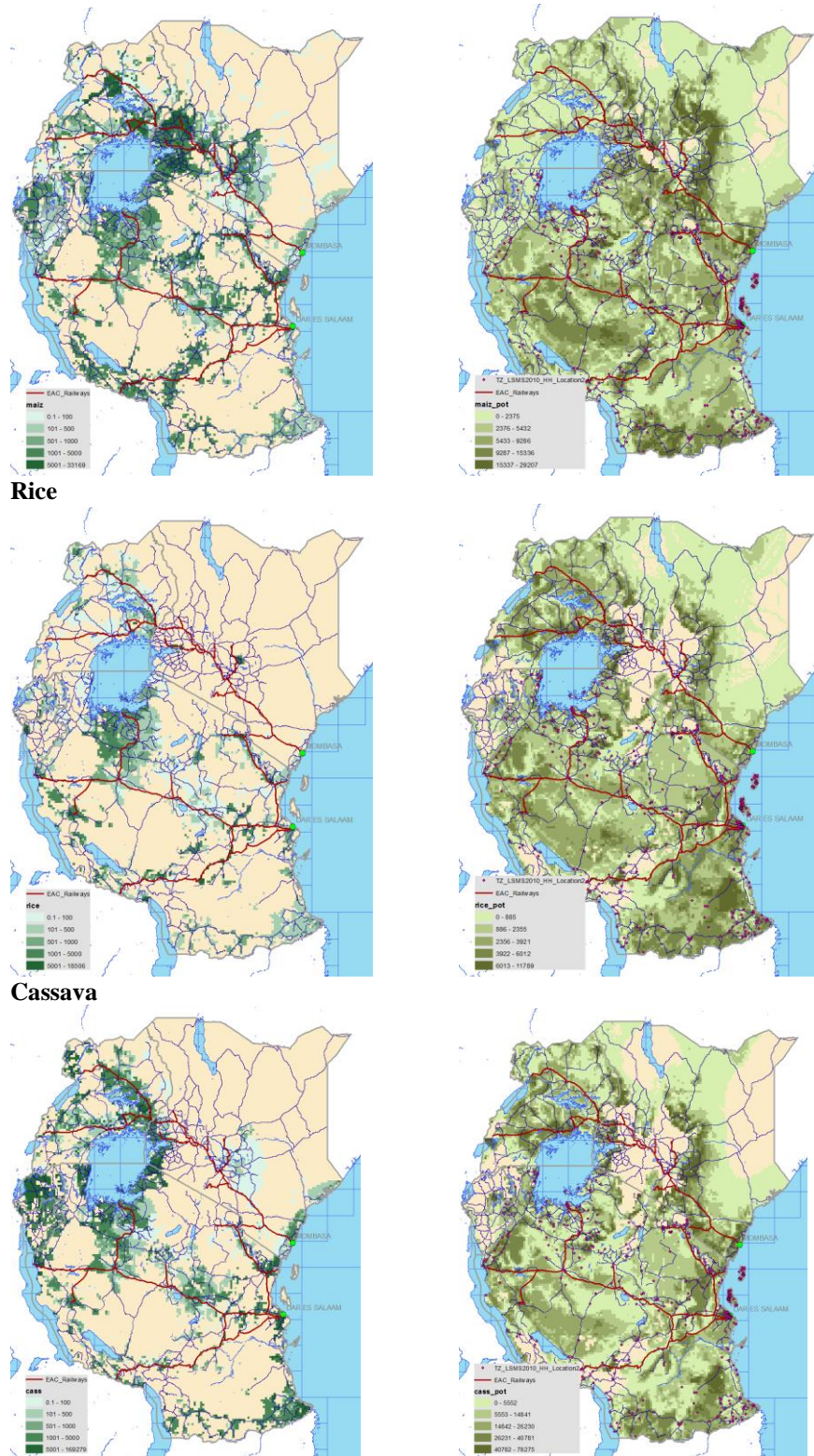
Source: FAOSTAT.

Figure 15. Tanzania: Major export crop production

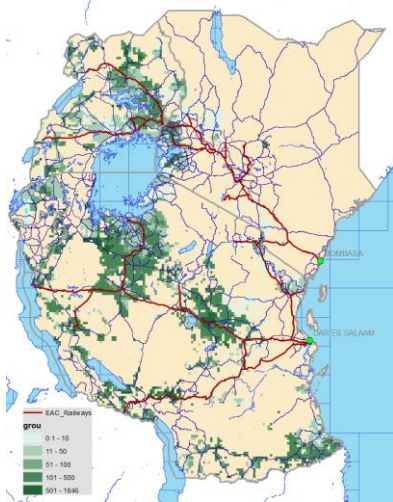


Source: FAOSTAT.

Figure 16. Comparison between actual and potential crop production areas
Actual production areas
Potential production areas



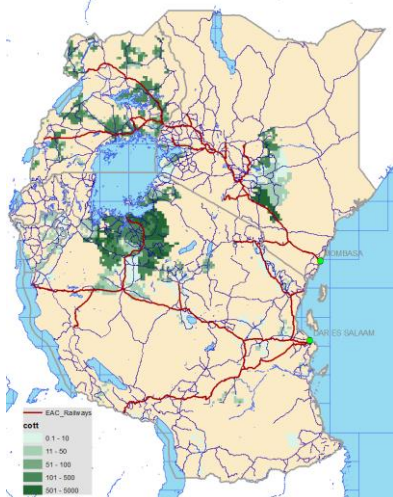
Groundnuts



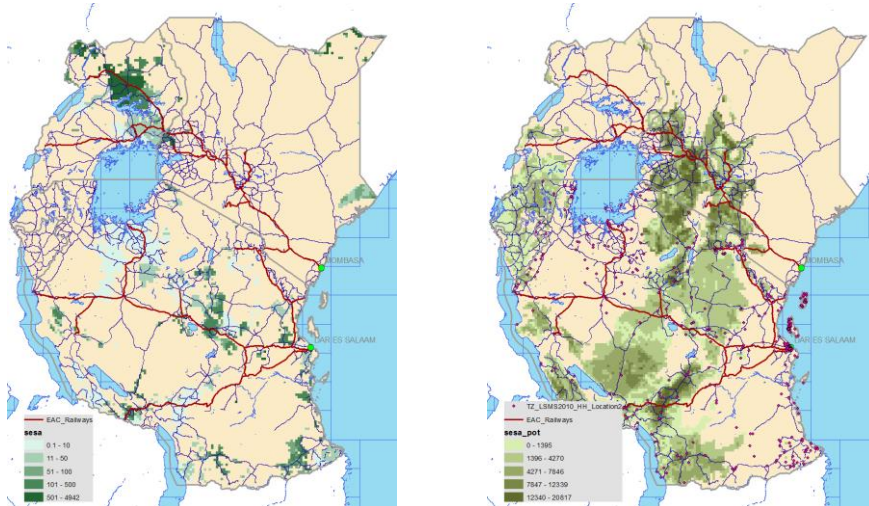
Tobacco



Cotton



Sesame



Source: SPAM Update 2010.

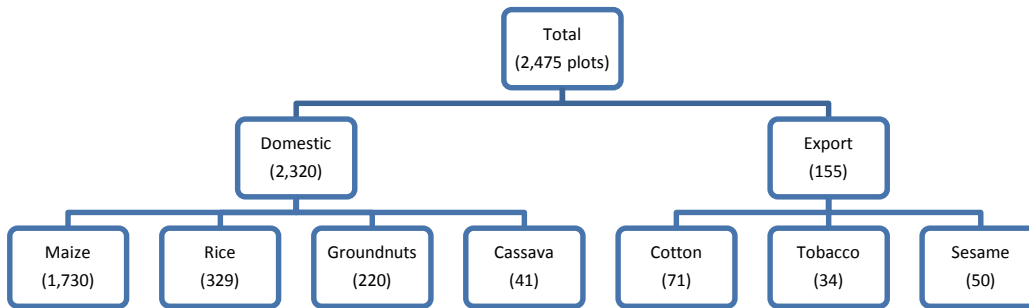
IV. DATA

Our data come from the 2010 LSMS in Tanzania. The original data cover 3,924 households, out of which 2,630 households were engaged in agricultural production in 6,038 plots. Our unit of analysis is a plot where a household grows one single crop. If a household produced more than one crop in a single plot, the plot is virtually divided into multiple observations. Excluding the observations with missing information, 2,475 observations are left for our analysis.¹⁰

In the sample, the domestic food crop production is dominant. Households cultivated 2,320 plots for domestic food crops and 155 plots for export crop, respectively. The detailed shares are shown in Figure 17. The vast majority of plots were used to produce maize, followed by rice and groundnuts. Among export crops, cotton was the most popular choice, followed by sesame.

¹⁰ For simplicity, these observations are called “plots” or “households” in the current paper.

Figure 17. Model of crop choice



As determinants of crop choice, both alternative- and individual-specific attributes are included in the model. The summary statistics are shown in Table 1. For alternative-specific characteristics X , agro-ecological crop suitability is fundamental, as shown in the literature. For instance, Kurukulasuriya and Mendelsohn (2007) find the particular importance of soil and weather conditions, such as precipitation and temperature, for farmers' crop choice.

Our crop suitability is measured by potential yield, which represents all these agro-climatic conditions. The data come from the Spatial Production Allocation Model (SPAM) updated by IFPRI. The SPAM basically disaggregates the subnational production data into the 10×10 km pixel-scale data using a spatially disaggregated data fusion and optimization approach with various agro-climatic conditions taken into account, such as weather conditions and land use and crop suitability. Given each household's location in the LSMS data, the crop suitability is defined by the amount of crops that can theoretically be produced under the low-input assumption.

From the economic point of view, crop prices may also be an important factor to incentivize farmers to choose a particular crop. According to the LSMS data, about 40 percent of the households were involved in some market transactions in Tanzania. Using those crop sales data, average local market prices are calculated at each locality (defined by a 50km radius).¹¹

¹¹ Given the relatively limited geographic coverage of the LSMS, the "locality" must be defined relatively broadly. If there is no observed crop price within a 50km radius, the price available in the closest location is used as a local price.

Transport accessibility is measured by the economic cost of transporting one ton of a crop from a production location to a primary destination. The destination for export crops is assumed to be one of the regional maritime ports, such as Dar es Salaam and Mombasa. For domestic food crops, the destination is the nearest large town/city with a population exceeding 100,000 population. Our transport cost variables include not only physical transport costs, such as road user costs and rail tariffs, but also opportunity time costs due to slow traffic movements and delays at transportation nodes, such as stations, borders and ports.

The economic transport cost differs significantly across the country. The cost to the port varies from \$128 per ton to \$182 per ton, depending on locality (Figure 8 above).¹² The cost to the nearest large town/city also varies from \$0.20 per ton to \$29 per ton (Figure 18).¹³

To modernize agriculture production, access to new technology may also be important. The literature suggests at least three production factors: irrigation, improved seed, and inorganic fertilizer (e.g., Gyimah-Brempong, 1987; Bravo-Ortega and Lederman, 2004). To avoid a further complication of the endogeneity problem in the model, the production factor accessibility is measured by the use of each input by “neighbors.”¹⁴ For fertilizer, the total amount of fertilizer used by neighbors is calculated. For irrigation and improved seed, the dummy variables are set to one if there is at least one neighbor who uses these inputs for a given crop. It is worth reiterating that these variables are crop- and individual-specific.

¹² The costs of port handling and fees are included, which amount to about \$96 and \$78 at the ports of Dar es Salaam and Mombasa, respectively.

¹³ For domestic food crops, another source of transport costs is available in the LSMS, which provides the distance to the “market.” Although it remains unclear how people define their markets, they are likely to be defined very locally. To do this, a unit transport cost is assumed to be \$0.11 per ton-km, which is a norm of the road user cost where a road is not paved and in poor condition in Africa. Interestingly, the estimation results turned out similar regardless of the definition of the destination, and therefore, the main analysis uses our city market definition.

¹⁴ The neighborhood is spatially defined by a 50km radius.

For (plot-specific) individual attributes Z , the basic characteristics of land plots are included, such as land area (ha) and land slope. The land area may be important to think of firms' crop choice, because large-scale farmers are likely to be less constrained to choose to grow export crops, which must of necessity involve certain risks. Small farmers may not have much flexibility to choose other than subsistence crops. The latter is defined by a dummy variable, which is set to one if a plot is slightly sloped or steep. The land title status is also included as a dummy variable. Only 10 percent of the households reported that they own land by the title deeds.

Following the literature (e.g., Moreno and Sunding, 2005; Edmeades et al., 2008; Klasen et al., 2013), the basic household characteristics, such as gender and school attainment of household head, household size, and household wage income, are also included in Z . In addition, access to other infrastructure services than transport is also different among households. Mobile access is included, given the recent evidence showing the ICT effects on farmers (Kiiza and Pederson, 2012; Zanello 2012).

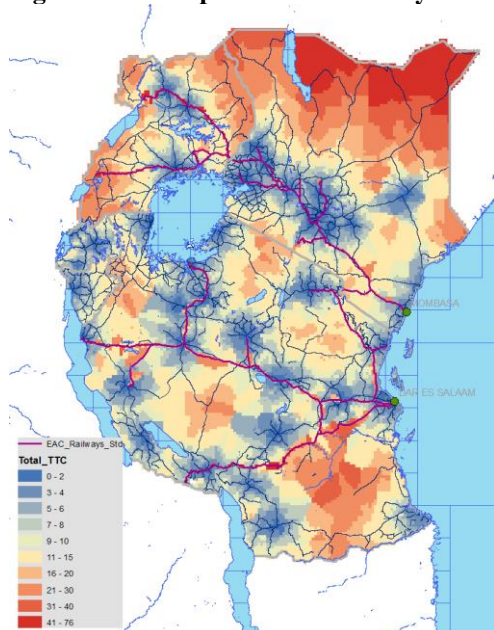
Access to electricity is also taken into account, which remains a significant challenge in Africa. In Tanzania, only 17 percent of households are electrified. In rural areas, the electrification rate is estimated at less than 1 percent. The literature argues various positive impacts on non-agricultural aspects, such as job creation and nonfarm income growth (e.g., Khandker et al. 2009; Dinkelman 2011). In theory, the farmers' crop choice can also be affected, particularly if they rely on electricity for irrigation water pumping.¹⁵ In our data, power access is defined by the dummy variable, which is set to one if a household relies on grid, solar or diesel power for lighting, and zero otherwise.

Finally, last-mile transport accessibility is measured by the distance to the nearest road. The data come from the LSMS. Most of the households live within 5 km distance from the

¹⁵ Irrigation remains to be developed in Tanzania. In the LSMS data, only 1.7 percent of plots have some irrigation systems. And the vast majority use gravity systems or rely on manual labor for pumping water. Only 0.2 percent of the surveyed plots have modern irrigation systems with motor pumps.

nearest road. The average is 1.4 km. Note that unlike economic transport cost, which varies depending on type of crop, this variable does not vary across crops but is location-specific. Regardless of which crop is grown and where the products are sold, farmers first have to get to a road. Therefore, this local accessibility is common across crop choices.

Figure 18. Transport costs to the city with more than 100,000 populations



Source: World Bank calculation.

Table 1. Summary statistics

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
Choice-specific variables:						
Crop price	Average crop sale price in a 50km radius; if not available, the price at the closest locality is used (TSh/kg)	2475	0.16	0.35	0.0004	2.18
Crop suitability	Potential crop yield estimated by SPAM Update 2010 (ton/ha)	2475	1.38	0.90	0.00	8.42
Transport cost	For export crops, transport costs to convey goods to the port; for domestic food crops, transport costs to the nearest city with more than 100,000 population (US\$/ton)	2475	15.28	33.25	0.01	182.86
Access to fertilizer	Fertilizer used for each crop by neighboring farmers within a 50km radius (kg)	2475	0.40	2.25	0.00	50.00
Access to irrigation	Number of neighboring farmers using irrigation within a 50km radius	2475	1.71	7.62	0	111
Access to improved seed	Dummy variable for the existence of any neighboring farmers using improved seed within a 50km radius	2475	0.38	0.49	0	1
Individual-specific variables:						
Area of plot	Area of land planted (ha)	2475	1.44	1.93	0.00	42.00
Steep slope	Dummy variable for the land gradient referred to as slightly sloped or very steep	2475	0.33	0.47	0	1
Land title	Dummy variable for land title held for each plot	2475	0.10	0.30	0	1
Electricity access	Dummy variable for households with access to electricity (including solar and self-generation) for lighting	2475	0.06	0.23	0	1
Mobile access	Dummy variable for households that spent some money on mobile phones in the last one month	2475	0.54	0.50	0	1
Distance from road	Distance from a road (km)	2475	1.44	2.55	0.00	28.00
Male household head	Dummy variable for male-head household	2475	0.85	0.35	0	1
HH head age	Age of household head	2475	45.90	13.53	18	92
HH head's year of schooling	Number of years of education that household head attained	2475	6.27	2.11	1	17
Household size	Number of household members	2475	6.23	3.42	1	35
HH wage income	Total amount of household wage income (TSh million)	2475	0.15	1.39	0.00	51.15
Instrumental variable:						
Crop price 2008	Average crop sale price in a 50km radius in 2008; if not available, the price at the closest locality is used (TSh/kg)	2475	0.18	0.35	0.005	1.96

V. ESTIMATION RESULTS

First, the conditional logit model is estimated with the individual-specific effects included (Table 2). The transport cost effect is found to be negative and significant, meaning that access to the market—defined by the port for export crops and by the nearest large city for domestic food crops—is important for farmers in choosing which crop. Among other inputs, availability of irrigation and improved seed are also important. The evidence is consistent with the literature (e.g., Moreno and Sunding, 2005; Dillon, 2011). Fertilizer availability has a positive coefficient, which is, however, statistically insignificant.

Among the individual-specific variables, local road accessibility tends to have a significant impact on the crop choice. All coefficients are negative, meaning that the likelihood of households growing a crop increases with proximity to the nearest road. The impact is particularly significant on maize, groundnuts, tobacco and cotton. Mobile access also has a positive impact on the choice of rice and groundnuts. This may be interpreted to mean that ICT access or market information is advantageous to grow these crops. Our data do not show that electricity access matters to crop choice. This may be because farmers in Tanzania have not yet used much electricity for agricultural purposes.

It is somewhat surprising that land title has a negative impact on crop choice. Our prior expectation was that secure land rights would allow farmers to be engaged in producing more valuable crops, which may require more inputs and investment. But our result is not supportive of this. It seems to add another piece of evidence of insignificant or weak impact of formal land rights on agriculture productivity in Africa (e.g., Place and Migot-Adholla, 1998; Bellemare, 2013). On the other hand, the evidence suggests that the size of land matters to crop choice. The likelihood of a crop being selected increases with land area.

Another unexpected result is that crop prices are negatively correlated with farmers' crop choice. The evidence means that more farmers choose to grow a crop of which the market price is lower. This is counter-intuitive, but perhaps likely to happen on the ground. Since

many farmers produce a particular crop, the local market price would decline. This raises an issue of endogeneity in the model.

To address this issue, an instrumental variable is constructed from the previous LSMS data in 2008. Using the same method, the average local market prices are calculated at each location. For export crops, the regional market prices are also lagged for 2 years. With the current prices replaced with the predicted values based on the first-stage regression, the conditional logit model is re-estimated.

The results turned out to be broadly the same as the above (Table 3). The price variable still has a negative coefficient: The lower prices, the more attractive crop choice. There remains concern that the time lag may not be enough to instrument the market prices. But the conventional exogeneity test cannot be rejected at the 5 percent significance level. The test statistic is 3.47, suggesting that the prices are likely to be exogenous. Therefore, the results can be understood to imply that the market prices may decline as too many farmers grow the same crops, or that farmers simply do not know market prices. In either case, farmers are not really effectively using the market prices to guide their crop choices.

Table 2. Conditional logit model

	Choice-specific variables	Individual-specific variables:					
		Maize	Rice	Groundnuts	Tobacco	Cotton	Sesame
Transport cost	-0.009 *** (0.002)						
Crop suitability	0.212 *** (0.053)						
Crop price	-0.620 *** (0.147)						
Access to fertilizer	0.067 (0.139)						
Access to irrigation	0.101 *** (0.020)						
Access to improved seed	0.810 *** (0.102)						
Area of plot		2.443 *** (0.666)	2.334 *** (0.668)	2.216 *** (0.669)	2.480 *** (0.667)	2.538 *** (0.668)	2.470 *** (0.672)
Steep slope		0.237 (0.346)	-1.225 *** (0.377)	-0.216 (0.371)	0.350 (0.481)	-1.066 ** (0.492)	0.362 (0.452)
Land title		-0.820 * (0.456)	-1.369 *** (0.497)	-1.491 *** (0.540)	-0.788 (0.724)	-1.073 * (0.614)	-1.763 ** (0.858)
Electricity access		0.743 (1.111)	0.950 (1.122)	0.466 (1.162)	0.951 (1.360)	-13.184 *** (1.113)	-0.420 (1.516)
Mobile access		0.375 (0.353)	0.902 ** (0.364)	0.739 ** (0.372)	0.469 (0.516)	0.501 (0.430)	0.509 (0.456)
Distance from road		-0.099 ** (0.041)	-0.044 (0.041)	-0.069 * (0.043)	-0.151 * (0.087)	-0.161 * (0.089)	-0.032 (0.045)
Male household head		-0.349 (0.484)	-0.669 (0.493)	-0.567 (0.501)	-0.007 (0.706)	-0.240 (0.564)	-0.752 (0.586)
HH head age		0.038 *** (0.010)	0.030 *** (0.010)	0.030 *** (0.011)	0.019 (0.017)	0.017 (0.012)	0.027 ** (0.012)
HH head's year of schooling		0.115 ** (0.057)	0.103 * (0.059)	0.017 (0.061)	-0.008 (0.101)	-0.059 (0.072)	0.187 ** (0.073)
Household size		0.046 (0.062)	0.029 (0.064)	0.083 (0.065)	0.118 * (0.072)	0.156 ** (0.067)	-0.049 (0.086)
HH wage income		-0.036 (0.037)	0.014 (0.036)	-0.081 (0.085)	-0.171 (0.363)	-0.069 (0.063)	-0.022 (0.056)
Obs.	17325						
Wald chi2	26724.8						
Pseudo R squared	0.5086						

Table 3. Conditional logit model with predicted crop prices

	Choice-specific variables	Individual-specific variables:					
		Maize	Rice	Groundnuts	Tobacco	Cotton	Sesame
Transport cost	-0.009 *** (0.003)						
Crop suitability	0.183 *** (0.057)						
Crop price hat	-0.835 *** (0.172)						
Access to fertilizer	0.073 (0.050)						
Access to irrigation	0.107 *** (0.019)						
Access to improved seed	0.866 *** (0.088)						
Area of plot		2.440 *** (0.467)	2.324 *** (0.469)	2.205 *** (0.470)	2.478 *** (0.472)	2.536 *** (0.468)	2.469 *** (0.473)
Steep slope		0.247 (0.348)	-1.240 *** (0.382)	-0.134 (0.374)	0.385 (0.493)	-1.030 ** (0.488)	0.416 (0.448)
Land title		-0.816 * (0.457)	-1.397 *** (0.500)	-1.508 *** (0.533)	-0.789 (0.706)	-1.072 * (0.618)	-1.765 ** (0.853)
Electricity access		0.772 (1.063)	0.965 (1.080)	0.471 (1.118)	0.969 (1.299)	-13.205 *** (640.693)	-0.419 (1.474)
Mobile access		0.438 (0.355)	0.960 *** (0.370)	0.760 ** (0.378)	0.537 (0.516)	0.569 (0.436)	0.565 (0.462)
Distance to road		-0.098 ** (0.053)	-0.042 (0.056)	-0.069 (0.057)	-0.150 * (0.098)	-0.161 * (0.084)	-0.031 (0.064)
Male household head		-0.430 (0.465)	-0.743 (0.481)	-0.637 (0.492)	-0.041 (0.719)	-0.315 (0.589)	-0.783 (0.580)
HH head age		0.036 *** (0.010)	0.027 *** (0.011)	0.029 *** (0.011)	0.020 (0.015)	0.016 (0.013)	0.030 ** (0.013)
HH head's year of schooling		0.108 * (0.068)	0.103 * (0.071)	0.017 (0.073)	-0.002 (0.100)	-0.058 (0.084)	0.214 *** (0.091)
Household size		0.048 (0.067)	0.034 (0.069)	0.083 (0.069)	0.116 * (0.076)	0.155 ** (0.072)	-0.045 (0.087)
HH wage income		-0.033 (0.107)	0.017 (0.105)	-0.085 (0.179)	-0.159 (0.620)	-0.064 (0.205)	-0.017 (0.185)
Obs.	17325						
Wald chi2	27029.9						
Pseudo R squared	0.5095						

To relax the IIA assumption, the nested logit model is estimated (Table 4). The joint null hypothesis that all the dissimilarity parameters are equal to one can be rejected, though some of the estimated parameters exceed one. The chi-square test statistics are 8.01 and 330.97 for the first and second models, respectively. Therefore, the IIA assumption does not seem to be likely to hold in our data.

The result is similar to the above: Transport costs adversely affect the farmers' crop choice. Even when the choice-specific effects are differentiated between domestic food and export crops, the coefficients are consistently negative and significant. Access to fertilizer, irrigation and improved seed is also found important. Larger farmers are more likely to select to grow export crops. Note that the baseline is a group of domestic crops. This may indicate a certain difficulty in promoting crop shift in Tanzania, where most farmers are small land holders.

It is also found that the choice response to crop prices is systematically different between the two types of crops. The price coefficient is positive for export crops, and negative for domestic crops, though neither is significant. It means that export crop producers are more receptive to market prices, but domestic food producers may not be well incentivized by market prices. The main results remains the same even with the predicted crop prices used (Table 5).¹⁶

To see the impacts in practical terms, the impacts are evaluated at the sample means. For instance, it is found that a 10-percent reduction in transport costs to the port could increase the probability of farmers choosing export crops by 1 percentage point. This may look small, possibly reflecting the current slow switch pattern. But the predicted change is relatively large compared with the marginal effects of crop suitability and crop prices (Table 6).¹⁷ The marginal effects of a 10 percent increase in crop suitability and crop prices are estimated at 0.02 and 0.07, respectively.

¹⁶ The positive coefficient on export crop prices is still insignificant at the conventional levels, but the *p*-value is 0.133.

¹⁷ The estimation result of Model (2) in Table 5 is used for prediction.

Regardless of whether the price variable is instrumented or not, other results are also broadly consistent with the conditional logit results. Fertilizer, irrigation and improved seed are all important determinants of the farmers' crop choice, especially when they grow export crops.

Table 4. Nested logit model

	Model (1)		Model (2)			
			Export crops		Domestic crops	
Choice-specific variables:						
Transport cost	-0.010	***	-0.026	***	-0.040	**
	(0.002)		(0.004)		(0.020)	
Crop suitability	-0.099	***	0.172		-0.011	
	(0.021)		(0.284)		(0.007)	
Crop price	-0.245	***	0.048		-0.079	
	(0.095)		(0.088)		(0.052)	
Access to fertilizer	0.441	**	0.465	*	0.042	
	(0.206)		(0.273)		(0.034)	
Access to irrigation	0.178	***			0.022	
	(0.032)				(0.014)	
Access to improved seed	1.705	***	3.776	***	0.145	
	(0.325)		(0.453)		(0.096)	
Type-specific variables: ¹						
Area of plot	0.070	**	0.068	**		
	(0.035)		(0.028)			
Steep slope	0.020		0.037			
	(0.189)		(0.203)			
Land title	-0.029		0.036			
	(0.308)		(0.327)			
Electricity access	-0.804		-0.713			
	(0.624)		(0.658)			
Mobile access	0.066		0.053			
	(0.180)		(0.189)			
Distance from road	0.000		0.024			
	(0.028)		(0.030)			
Male household head	-0.014		-0.029			
	(0.226)		(0.232)			
HH head age	-0.013	**	-0.020	***		
	(0.006)		(0.007)			
HH head's year of schooling	-0.067	**	-0.103	***		
	(0.034)		(0.038)			
Household size	0.043	*	0.018			
	(0.024)		(0.026)			
HH wage income	-0.056		-0.124			
	(0.042)		(0.086)			
Obs.	17325		17325			
No. of cases	2475		2475			
Wald chi2	898.19		385.81			
Dissimilarity parameters:						
Export crops	0.625		1.120			
	(0.138)		(0.242)			
Domestic crops	0.851		0.077			
	(0.162)		(0.051)			

1/ The export crop specific coefficients are shown, while domestic crops are used as a baseline.

Table 5. Nested logit model with predicted crop prices

	Model (1)		Model (2)			
			Export crops		Domestic crops	
Choice-specific variables:						
Transport cost	-0.013	***	-0.027	***	-0.040	**
	(0.003)		(0.004)		(0.020)	
Crop suitability	-0.106	**	0.175		-0.010	
	(0.049)		(0.264)		(0.008)	
Crop price hat	-1.230	**	0.163		-0.121	
	(0.548)		(0.109)		(0.102)	
Access to fertilizer	0.229	*	0.407		0.020	
	(0.134)		(0.278)		(0.020)	
Access to irrigation	0.125	**			0.013	
	(0.050)				(0.010)	
Access to improved seed	0.989	**	3.844	***	0.078	
	(0.504)		(0.469)		(0.066)	
Type-specific variables: ¹						
Area of plot	0.090	**	0.070	**		
	(0.045)		(0.028)			
Steep slope	-0.080		0.010			
	(0.186)		(0.202)			
Land title	-0.151		0.020			
	(0.306)		(0.327)			
Electricity access	-0.906		-0.728			
	(0.615)		(0.658)			
Mobile access	-0.014		0.044			
	(0.180)		(0.188)			
Distance from road	-0.008		0.024			
	(0.030)		(0.030)			
Male household head	-0.105		-0.041			
	(0.213)		(0.230)			
HH head age	-0.018	***	-0.021	***		
	(0.006)		(0.007)			
HH head's year of schooling	-0.094	***	-0.109	***		
	(0.034)		(0.038)			
Household size	0.064	***	0.017			
	(0.023)		(0.026)			
HH wage income	-0.045		-0.123			
	(0.039)		(0.085)			
Obs.	17325		17325			
No. of cases	2475		2475			
Wald chi2	544.03		385.59			
Dissimilarity parameters:						
Export crops	1.875		1.071			
	(0.633)		(0.245)			
Domestic crops	0.507		0.043			
	(0.247)		(0.036)			

1/ The export crop specific coefficients are shown, while domestic crops are used as a baseline.

Table 6. Predicted change in probability of choosing export crops

Assuming a 10 percent improvement in each factor:	Change in probability (%)
Transport costs	1.016
Crop suitability	0.018
Crop prices	0.069
Input accessibility:	
Fertilizer	0.002
Irrigation	n.a.
Improved seed ¹	55.639

1/ The predicted change is for discrete change of a dummy variable from 0 to 1.

VI. CONCLUSION

Africa is abundant in natural resources and has great potential for agriculture. International commodity prices have been driven up by strong global demand for food and been favorable to many African countries. However, there is no clear evidence to show a sharp supply response in Africa. The farmers' shift toward cash and export crops seems to be particularly slow. There are many constraints on the farmers' crop choices.

The paper casts light on this problem in the case of Tanzania. The paper examined the impacts of not only agro-climatic conditions, such as crop suitability and soil and weather conditions, but also economic infrastructure. Tanzania is a traditional exporter of coffee, tea, cotton, tobacco, and more recently, sesame. But among others, transport connectivity to markets is a constraint. The paper shows that the transport costs to the port vary significantly from \$128 per ton to \$182 per ton, depending on locality.

Given the location- and household-specific characteristics, conditional and nested logit models were estimated. The results show that transport costs are important for farmers to choose a particular crop. Farmers are less likely to grow export crops, such as cotton and tobacco, if the transport costs are high to get to the port. The connectivity to the domestic

market is also found to be an important crop determinant for food crops, such as maize and rice. Among other inputs, access to irrigation and improved seed is also important for farmers to make crop choices. There is an indication that farmers are not really effectively using the market prices to guide their crop choices, even after the endogeneity of local prices is taken into account. If correct, this implies that further efforts are needed toward distributing the market information effectively and providing technical services to adopt new technologies for cash crop production.

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