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Stages of Agricultural Commercialization in Uganda: The Role of the Markets[1]

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Abstract

Agricultural commercialization has become the centerpiece of the sector development strategy in Uganda in recent years. Nevertheless the low market participation of most smallholders in the country remains a fact. We employ semi-parametric regression techniques to analyze the current state of market participation and production diversification and to identify the determinants of commercialization in Uganda. We find that the key constraint to agricultural commercialization in Uganda is inadequate access of farmers to infrastructure and assets, both physical and human. Those with access to assets and closer to markets engage actively in the markets, while those lacking one or more of these essential ingredients largely do not. These findings are in line with the recent literature on smallholder market participation in Africa. We also find that commercialization proceeds in stages. When farmers have appropriate incentives and access to markets, they do not immediately separate production and consumption decisions. Instead they first diversify their production portfolios before subsequently increasing commercial specialization. The result is a U-shaped relationship between commercialization and diversification.

Keywords: commercialization, diversification, smallholder agriculture, Uganda, semi-parametric regression

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1. Introduction

Agricultural commercialization has become the centerpiece of the sector development strategy in Uganda in recent years. Both the new *National Development Plan* and the *Development Strategy and Investment Priorities for the Agriculture Sector* emphasize the need to break the vicious cycle of subsistence and promote greater market participation by farmers. Both documents advocate targeted support to agriculture, given the farmers' weak response to 'right prices' in Uganda.[3] The government has increased investments in inputs through advisory services and other projects, as a part of technology dissemination, often focusing on larger farms. Spending on goods and services has accounted for up to 40 percent of total sector budget in recent years, and its share is growing (Gautam and Zorya, 2010). The objective is to improve access to technologies and promote the shift from producing food staples to higher-value products.

The results have not been impressive so far. Agricultural growth has slowed from 5.4 percent per annum in 1998-2001 to about 1.1 percent per annum in 2004-2008, according to the national accounts. Although the observed significant poverty reduction in Uganda, increased agricultural exports of both cash crops and food staples, and lower food inflation than in neighboring countries all suggest that agricultural growth has been higher than reported in the national accounts (Zorya *et al.*, 2010), nevertheless the low market participation of most smallholders remains a fact. We present evidence below that the least commercialized 25 percent of farmers sell only 4 percent of their produce and purchase inputs worth only 1 percent of the value of their production. The median level of output commercialization is less than 30 percent. In this study we analyze the current state of market participation and production diversification and identify the determinants of commercialization to investigate why the current policy instruments are not suitable and/or sufficient to promote commercialization. Based on this analysis we suggest suitable policy alternatives.

We find that the key constraint to agricultural commercialization in Uganda is inadequate access of farmers to infrastructure and assets, both physical and human. Those with access to assets and closer to markets engage actively in the markets, while those lacking one or more of these essential ingredients largely do not. These findings are in line with the recent literature on smallholder market participation in Africa (Barrett, 2007; Jaleta *et al.*, 2009). We also find that commercialization proceeds in stages. When farmers have appropriate incentives and access to markets, they do not immediately separate production and consumption decisions. Instead they first diversify their production portfolios before subsequently increasing commercial specialization.

These findings may help explain why there has been little progress in promoting commercialization in Uganda so far. Public expenditure on inputs, which have been prominent in agricultural budget, does not address the primary constraint for commercialization but rather diverts resources from infrastructure, human development, and advisory services. The active promotion of higher-value products through the National Agricultural Advisory Services (NAADS) has positive but limited potential at this stage, because the pre-conditions for specialization in these products are generally not in place for smallholders. Targeting a few larger farms does not produce positive spillovers to smallholders and may even make these large farms even less efficient. To achieve the objectives of agricultural commercialization, the government is advised to address the underlying constraints by investing in rural roads, other

[3] Mathews *et al*. (2006) find minimal agricultural distortions in Uganda in contrast to many other African countries.

infrastructure, regional integration, human development, the land market, research and advisory services, and rural finance/matching grants.

The rest of this paper is structured as following. In Section 2 we briefly discuss the recent literature on smallholder commercialization and examine the current extent of agricultural commercialization and specialization in Uganda. In Section 3 we discuss the empirical methodology we use to analyze the determinants of commercialization, and in Section 4 we present the results of this analysis. Section 5 closes with policy recommendations and conclusions.

2. The Current Extent of Agricultural Commercialization and Specialization in Uganda

What is agricultural commercialization? At the farm household level, agricultural commercialization is more than marketing agricultural products. It is attained when household product choice and input use decisions are made based on the principles of profit maximization. Commercialization is not restricted only to cash crops as traditional foods crops are also frequently marketed to a considerable extent. Commercialized households separate production and consumption decisions and participate in the markets for both staple and industrial products to maximize profits (see Jaleta *et al.*, 2009 for the discussion of concepts of smallholder commercialization).

Commercialization is a part of the structural transformation and diversification of agriculture. At the early stages of development, most farms are subsistent, specialized in producing one or several food staples (Barrett, 2007; Emran and Shilpi, 2008). In the absence of markets and with the perceived high price and yield risks, the aim of food self-sufficiency at the household level dominates. An increase in the extent of the market and increased household human capital lead to higher and less volatile prices for non-staple crops, inducing farmers to allocate some land to these crops. Nevertheless, subsistence considerations along with price and yield risks in an environment in which insurance markets are missing force farmers to adopt more diversified crop portfolios rather than specialize completely in non-subsistence crops. When the extent of market reaches a threshold, price risk is reduced sufficiently to allow farmers to specialize again, but unlike the initial subsistence specialization, production and consumption decisions are now separated. Therefore, the two dimensions of structural change – diversification/specialization and commercialization – are interlinked by a U-shaped relationship: as commercialization proceeds, it is initially accompanied less, and then later more specialization. Below we study the extent of agricultural commercialization and diversification in Uganda and how it differs from other developing countries.

Many different metrics for commercialization and specialization have been proposed in the literature (Barrett, 2007; Jaleta *et al.*, 2009). Concentration is also defined in many ways and there is no particular reason in favor of one or the other (Imbs and Wacziarg, 2004). In our empirical analysis we employ output and input side commercialization (von Braun and Kennedy, 1994; see definitions below) as well as a Herfindahl index of crop specialization due to their intuitive simplicity and best fit to the data at hand:

a. *Output commercialization index* = the value of gross sales[4] of agricultural output divided by the value of agricultural production. This index equals 0 for subsistence and rises asymptotically to 1 as sales increase.

b. *Input commercialization index* = the value of purchased agricultural inputs divided by the value of agricultural production. This index equals 0 for subsistence and theoretically it is unbounded, as purchases can exceed sales/output.

c. *Land concentration index* (Herfindahl index) = the sum of squared crop land shares over all crops that a farm produces. As a farm's crop portfolio becomes increasingly specialized, this index rises asymptotically to 1.

To generate these indices, we use data from the 2005/06 Uganda National Household Survey (UNHS). The UNHS covers about 750 enumeration areas (communities) and contains data on agriculture production and marketing as well as socio-economic data at the household level, and data on infrastructure, services and markets at the community level. Additionally we complement the UNHS survey data with information on population, elevation, and the coordinates of urban units in Uganda[5]. After some cleaning, we arrive at 5,200 urban units.

Figure 1 presents the profile of the output and input commercialization indices for crop and livestock sectors combined. Before discussing the figure, we would like to mention that we analyzed output and input commercialization separately for the crop and livestock sectors. The results indicate that the livestock sector does not contribute much to the overall pattern of commercialization in Uganda. The only difference that emerged is that the livestock sector is more subsistent than the crop sector. Based on this and without loss of generality, in the following we discuss only the results for crops and livestock combined.

Most farmers in Uganda display low levels of output and input commercialization (Figure 1, panels a). At the bottom end of the distribution, 25 percent of the households sell less than 4 percent of their produce to the market, and at the top end only 25 percent sell more than a half of their total production. On the input side, the 25 percent of the household at the lower end of the distribution purchase inputs worth less than 1 percent of their total agricultural production value, and this proportion is only 23 percent for the 25 percent of the households at the upper end of the distribution. This indicates that smallholders in Uganda overwhelmingly use non-traded inputs.

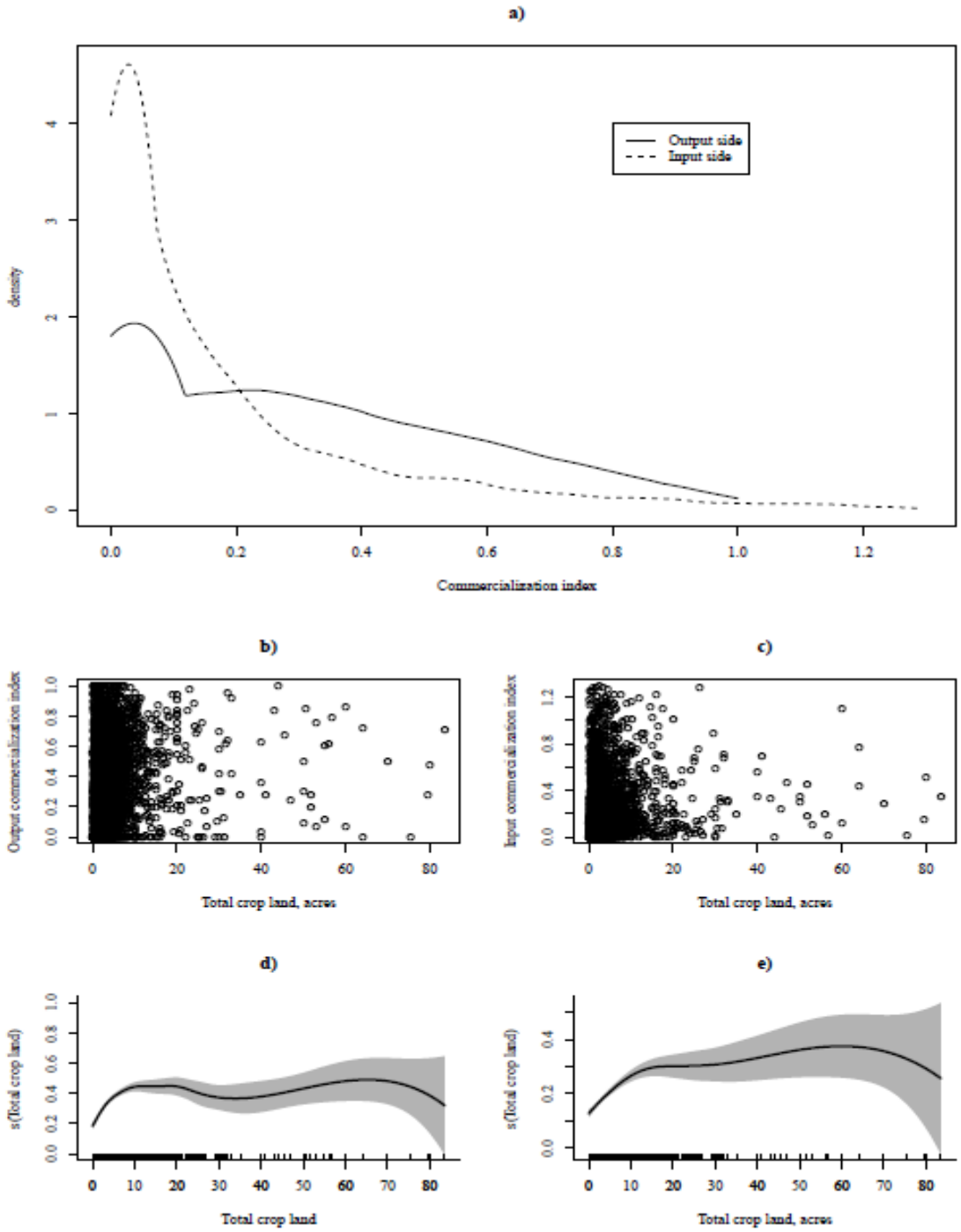
The scatter plots of output and input commercialization indices against farm size in Figure 1, panels b and c, reveal no clear visual patterns due to the large number of data points. However, non-parametric estimates using smoothing splines[6] do reveal some interesting patterns (Figure 1, panels d and e). Both plots demonstrate that commercialization increases as farm size increase until it stabilizes at approximately 10 and 15 acres for output and input commercialization, respectively. Comparing panels d and e shows that adding more acres quickly brings a household into a food surplus situation, while purchased input use increases more slowly.

[4] Some papers also use an index of net sales in addition to that of gross sales. However, while the net sales index is suitable for analyzing commodity-level commercialization, it is less so for aggregate commercialization. Furthermore, Barrett (2007), in his survey of articles in this field, does not find any significant differences between using net and gross sale indices.

[5] http://www.fallingrain.com/world/UG/

[6] The package 'gam' in R with automatic knot selection was used to generate these splines.

Figure 1: Indices of output and input commercialization crops and livestock combined: densities and relationship with farm size



*Source: Own presentation based on the 2005/06 UNHS III. In the bottom panels shaded areas are 2*standard error bands and ticks on the x-axis depict the density of the support.*

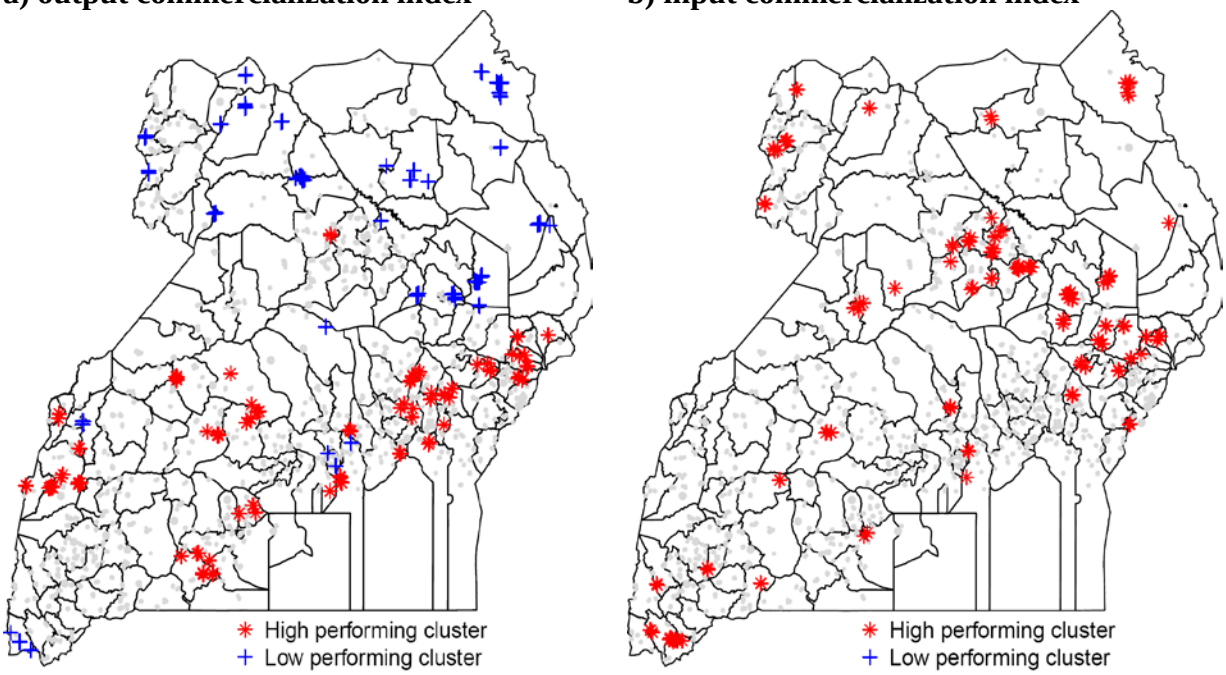
To explore the spatial distribution of output and input commercialization, we employ a local variant of the Moran's I statistic called the Local Indicator of Spatial Association (LISA, Anselin, 1995). The LISA measures spatial association for each observation in the data set, and is useful for identifying significant local spatial clusters.[7] The results in Figure 2 show that

[7] A Euclidean distance-based spatial weighting matrix indicates which households are considered neighbors to one another in calculating the LISA. We define all households that are within 6 km of each other as neighbors. This

clusters of above average output commercialization (at the 5% Bonferroni-adjusted significance level) are especially frequent in places that correspond to zones of high agricultural potential and high population density in Uganda (see Figure 3, panels a and d). Many of the clusters of significantly above average input commercialization are located along the main trunk road that stretches from Kenya to Sudan through Uganda, in other words where market access is high (compare Figure 3, panel b). These patterns suggest that the extent of the market (population density), market access and natural conditions have important influences on the commercialization and specialization of household farms in Uganda, hypotheses that we explore more rigorously below.

Figure 2: Spatial clustering of output and input commercialization indices in Uganda

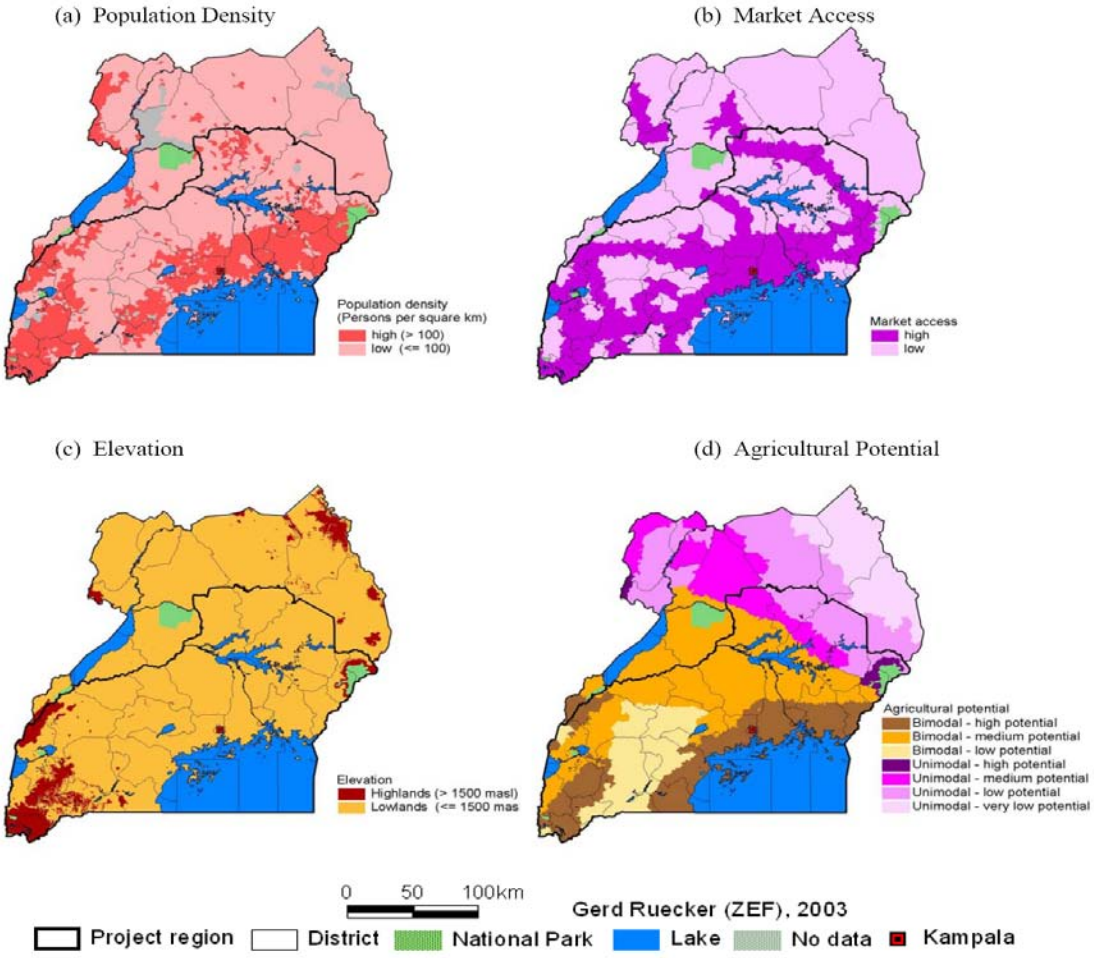
a) output commercialization index **b) input commercialization index**



Source: own calculation. Stars (*) and crosses (+) denote neighboring observations with significantly similar high and low scores (at the 5% Bonferroni adjusted significance level), respectively.

critical distance was determined based on the distribution of the distances between all the pairs of households in the dataset. Details are available from the authors.

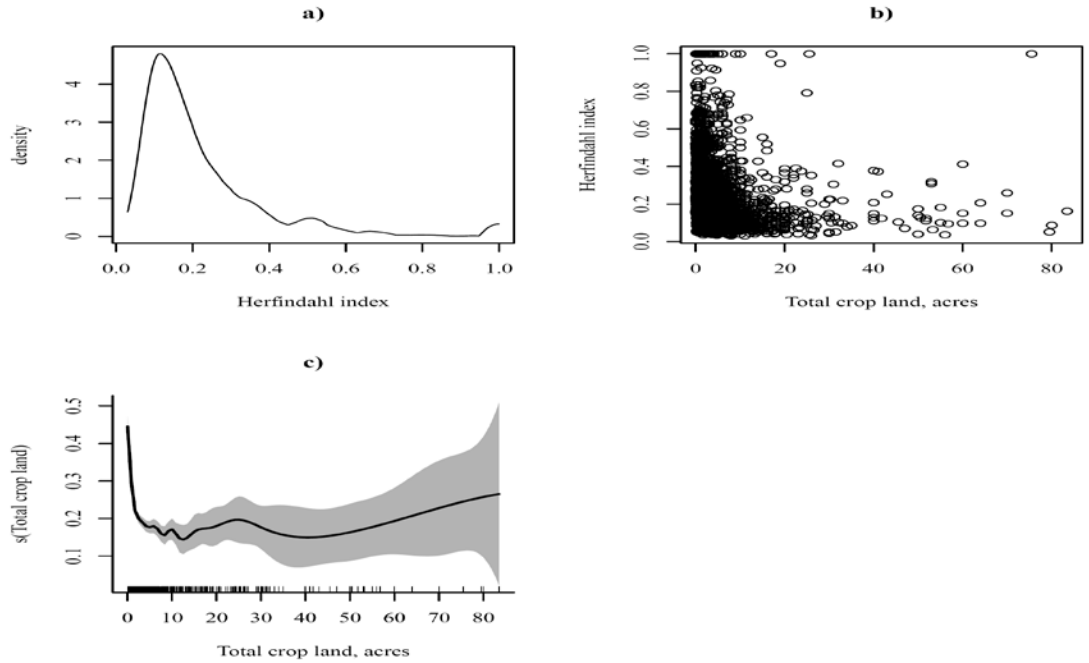
Figure 3: Agricultural potential, population density, market access and elevation in Uganda



Source: Rücker et al. (2003).

We next consider specialization. Figure 4 shows that Ugandan farmers are quite diversified. The distribution of the Herfindahl index of land-use concentration in panel (a) reveals that about 75 percent of all households have a value below 0.27. The mode and the median of this distribution are 0.11 and 0.17, respectively. To put these values into perspective, note that a farm that dedicates equal thirds of its land to three different crops would have a Herfindahl index of 0.27. Panels b and c of Figure 4 present the scatter plot of the Herfindahl specialization index against farm size measured in total household crop area, and the non-parametric estimate of the relationship between these variables, respectively. The non-parametric estimate shows that as farm size increases up to roughly 10-12 acres, households tend to diversify their production. Above this threshold there is some evidence of increased specialization in much larger farms, but the 2-standard error bands and hence the uncertainty associated with the non-parametric estimates also increase over this range, which contains relatively few observations.

Figure 4: Land concentration indices in Uganda



*Source: Own presentation based on the 2005/06 UNHS III. In the bottom panel shaded areas are 2*standard error bands and ticks on the x-axis depict the density of the support.*

3. Modeling the Determinants of Agricultural Commercialization in Uganda

3.1 Determinants

Barrett (2008) proposes a formal model of smallholder commercialization in which a representative household maximizes its utility, defined over the consumption of a vector of agricultural commodities and other tradables. It earns income from production and any sales of crops, and off-farm earnings. The household's commercialization and specialization status is determined by its transaction costs that depend on public goods and services (roads accessibility, extension services etc), household-specific characteristics (education, gender, and age), household assets, liquidity from non-farm earnings and net sales volumes.

Other literature categorizes these determinants of agricultural commercialization and specialization broadly into external and internal drivers (Jaleta *et al.*, 2009).[8] The external forces, which are beyond the household's control, are population growth and demographic change, technological change and the introduction of new commodities, development of infrastructure and market institutions, development of the non-farm sector and the broader economy, rising labor opportunity costs, and macroeconomic, trade and sectoral policies that affect prices and other driving forces (Pingali and Rosegrant, 1995). Factors such as resource endowments are household specific and considered as internal drivers. Below we describe these forces in more detail and define the variables used in our empirical analysis.

Among the internal drivers we include household endowments (land, farm implements, and human capital) as essential determinants of marketable surplus production at the household level. Larger farm holdings, for example, enable households to realize economies of scale by adopting modern technologies. We use the size of a *household's agricultural land holdings* and *the value*

[8] For a schematic representation of these forces, see von Braun and Kennedy (1994), p. 13.

of its agricultural and non-agricultural assets to controls for this. Human capital comprises education, experience, skills, capabilities etc. In our analysis we use the level of *education of the household head*. Other internal drivers include the *age of the head of the household*, *his/her sex*, and *household size*.

Among the key external factors of commercialization and specialization we include the extent of the market. Urbanization and higher incomes from economic growth increase the demand for marketed agricultural products which will tend to increase commodity prices and stimulate specialization and agricultural production for the market. However, recent literature on stages of diversification in the aggregate economy and within manufacturing and agriculture hypothesizes that the interplay of subsistence and risk considerations and scale economies implies a non-linear relationship between agricultural specialization and the extent of the market (Emran and Shilpi, 2008). We define the *extent of market i* as the weighted sum of the sizes of the *K* urban units around *i*:

$$\text{EXT.MKT}_i = \sum_{j=1}^{K} m_j \exp(-d_{ij})$$

where m_j is the market size of urban unit *j*, $\exp(-d_{ij})$ is the weight of urban unit *j*, and d_{ij} measures the distance between *i* and *j*. According to this equation, the extent of market *i* grows with the size and proximity of the urban units that surround it. This definition of the effective market size allows for the possibility that a farmer might not trade with the nearest urban unit but rather with a unit that is farther away but larger, a possibility which would be ruled out if we only considered the size of the nearest urban unit. Due to data limitations, we measure the market size m_j of urban unit *j* by its population. This might be a limitation of the analysis, since population might not reflect a 'true' economic size of the market.

To explore how a household's diversification/specialization evolves as its income grows, we include *consumption expenditure* in the analysis. The literature on stages of diversification finds a U-shaped relationship between a household's income and its specialization (Imbs and Wacziarg, 2003). As per capita income grows, production initially becomes more diversified, and only after a threshold level of income is crossed does it become more specialized.

Infrastructure plays an important role in commercialization. We capture *transport infrastructure* as a dummy that indicates whether a given community has at least one of the following transport infrastructure units: feeder roads (all or only dry season), trunk roads, railway stop, waterway transport, truck/pick-up for transporting inputs/produce.

Commercialization can also benefit from better access to consumer, input, and output markets via lower search, monitoring, and transport costs. The variable *travel time to consumer markets* controls for this in the analysis. It measures the travel time to the most common local consumer market using the standard means of transport.

Financial infrastructure controls for access to financial institutions/infrastructure. The variable is a dummy that equals 1 if there is a bank branch office or microcredit institution in the community. Better access to credit facilitates technological improvement and the introduction of new commodities on a farm, which can increase commercialization and specialization. Access to financial infrastructure can also provide hedges against price and yield risks thus allowing farmers to specialize more.

The variable *off-farm employment* is a dummy that equals one if a household member is employed off-farm. Off-farm income alleviates production and prices risks to some extent, thus resulting in higher levels of commercialization and specialization.

Elevation measures the altitude at which a household is located and mainly controls for differences in natural conditions. Elevation has a major influence on agro-climatic conditions, soil erosion processes and crop management in highland regions (Ruecker *et al.*, 2003).

All of the data required to generate these variables it taken from the UNHS mentioned in Section 3, with the exception of *extent of the market*. To generate this variable, we complement the UNHS data with information on population, elevation, and the coordinates of urban units in Uganda (see http://www.fallingrain.com/world/UG/). Descriptive statistics for all of the variables employed in our analysis are provided in Table 2 (Annex).

3.2 Model Specification

We use the semi-parametric regression (Hastie, 1992), to model the determinants of the farm level commercialization and specialization in Uganda. The model is formally stated as:

$$y = X\beta + s_1(z_1) + ... + s_q(z_q) + \varepsilon$$

In our application, the dependant variable y is a farm level commercialization and specialization, which is modeled as functions of a series of covariates in *X* and in *Z*. This model contains both linear parametric ($X\beta$) and non-parametric additive terms ($s_1(z_1) + ... + s_q(z_q)$). The $s_i(z_i), i = 1,...,q$ are smooth functions of covariates $z_i (i = 1,...,q)$. They are estimated using penalized regression splines, and by default use basis functions for these splines that are designed to be optimal, given the number basis functions used.

The main advantage of the semi-parametric approach over pure parametric regression (see for example Emran and Shilpi, 2008) is that we do not impose a functional form on the relationships between the dependent outcomes y and the covariates in Z. This is an important advantage, as linear regression would fail to capture more complex non-linear relationships between y and the variables in Z. Misspecification and invalid inference would be the result. Sometimes covariates are transformed into polynomial or logarithmic terms in an attempt to capture non-linearities, but these transformations will at best approximate the underlying non-linearities, so that misspecification and invalid inference remain. The advantage of non-parametric flexibility will become apparent below when we for example estimate relationships between commercialization and diversification/specialization that are roughly U-shaped, but with significant departures (such as threshold values and asymmetries) from simple quadratic or other approximations.

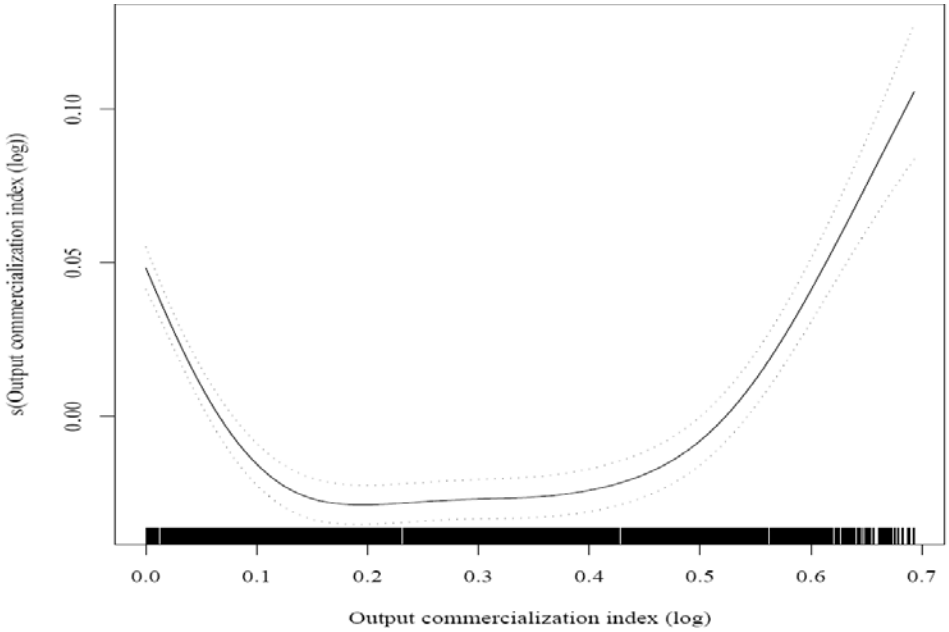
These advantages come at a cost in terms of ease of interpretation. While parametric regression produces point estimates of parameters that can be interpreted as first derivatives, elasticities, or rates of change, etc. depending on the functional specification employed, non-parametric regression by definition cannot provide such parameter estimates. However, non-parametric estimation does permit inference on whether a covariate in Z makes a significant contribution to explaining y. And it is possible to graph the estimated relationship between a covariate in Z and y, and to estimate confidence bands around this relationship that can help identify ranges of the covariate over which the relationship is estimated with precision, and other ranges over which the estimated relationship must be interpreted with caution.

We include in X all of the determinants of commercialization/specialization that are measured as qualitative or dummy variables, as the impact of such variables can only be estimated as a parametric shift effect. Z includes all of the remaining quantitative variables listed in the previous section.

4. Results

Before we discuss the semi-parametric regression results in detail, it is useful to look at the relationship between market participation (commercialization) and diversification in Figure 5, because understanding this relationship eases the interpretation of the semi-parametric regression results. The estimated fit indicates that there is a distinctly U-shaped non-linear relationship between commercialization and diversification in Uganda. The narrow 2 * standard error bands indicate that this relationship is estimated with precision. Initially as farmers commercialize they also diversify their production portfolios, until an output commercialization level of roughly 16 percent of output is attained. Above this level, diversification remains more or less constant until sales account for roughly 40 percent of total agricultural production. The great majority of the households in the dataset are located in this range of initially increasing and then constant diversification (see the density of output commercialization in Figure 1, panel a). As commercialization increases above 40 percent, specialization increases rapidly. This U-shape relationship implies that promoting certain technologies through NAADS, for example, will not necessarily result in the immediate increased specialization in the corresponding commodities. Farmers will maintain diversified production portfolios until they have adequate access to market and factors of production to fully disconnect their production and consumption decisions.

Figure 5: The estimated non-parametric relationship between output commercialization and the (logged) Herfindahl index of specialization



*Note: The dashed curves are pointwise 2*standard-error bands, which can be viewed as approximate 95 percent pointwise confidence intervals.*
Source: Own presentation based on the 2005/06 UNHS III. For a discussion, see section 5 below.

Table 1 presents semi-parametric regression results for three models, one each for the logged output commercialization index, the logged input commercialization index, and the logged Herfindahl index of specialization (land use concentration). All three models include five parametric terms (including the intercept) and eight non-parametric terms. The fit of the models is quite good for the cross-sectional setting (R^2 between 30 and 40 percent), except for the input commercialization model (R^2 under 10 percent). As discussed in Section 3 above, levels of input commercialization are very low in Uganda. Hence, it is not surprising that a model that is designed to explain input commercialization performs poorly. In the following we therefore focus the discussion on the results for output commercialization and specialization.

Table 1: The determinants of commercialization and specialization in Uganda: semi-parametric regression

Dependent variable	Log (output commercialization)	Log (input commercialization)	Log (Herfindahl index - specialization)
Parametric variables (coefficient estimates)	***Estimate***	***Estimate***	***Estimate***
Intercept	0.198	0.219***	0.213***
Transport Infrastructure	0.025**	-0.023	-0.034***
Sex of HH Head	0.038***	-0.028**	0.012***
Off-Farm Employment	-0.005	0.025**	0.008***
Financial Infrastructure	0.039***	0.028	0.015*
Semi-parametric variables (significance of smooth terms)	***p-value***	***p-value***	***p-value***
Internal determinants			
s(Size of the Household)	0.000	0.000	0.000
s(Age of the HH Head)	0.000	0.001	0.000
s(Education of the HH Head)	0.000	0.067	0.002
s(Agricultural Cultivated Land)	0.000	0.000	0.000
s(Log HH Agricultural and Non-Agricultural Assets)	0.000	0.009	0.000
S(Log Consumption Expenditure)			0.013
External determinants			
s(Log. Extend of Markets)	0.179	0.002	0.000
s(Travel Time to Common Consumer Market)	0.000	0.305	0.000
s(Elevation)	0.001	0.000	0.000
R-sq (adjusted)	*32.20%*	*9.36%*	*39.70%*
Deviance explained	*16.10%*	*6.81%*	*20.60%*
Number of observations	*4,187*	*4,187*	*4,191*

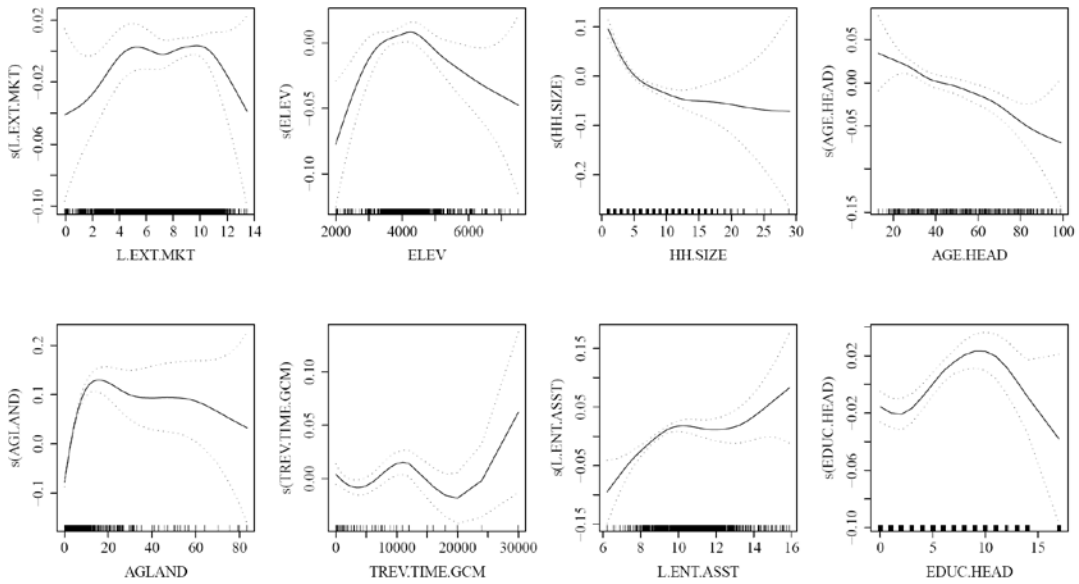
*Note: Significance codes: *** 1 percent; ** 5 percent; and * 10 percent. Descriptive statistics for all variables are provided in Table 2 (Annex).*
Source: Own calculations.

Parametric effects are reported in Table 1 and have the expected pattern across models. Access to *transport infrastructure* has a significant positive effect (2.5 percent) on output commercialization and it also increases diversification (reduces specialization). Given that most Ugandan farms are concentrated on the downward sloping arm of the U-shaped relationship between diversification and commercialization depicted in Figure 5, the access to transport increases the latter and reduces the former.

Access to financial institutions has the strongest impact in the output commercialization model. But it does not affect the input commercialization or diversification, and its elasticity is close to that of *sex of the household head*. Male-headed households tend to sell more output and specialize in fewer crops, indicating the strong interplay of the determinants of commercialization. Finally, *off-farm employment* has a positive and significant impact on input commercialization and specialization. The availability of off-farm income for the members of a household increases the use of inputs and specialization by 2.5 percent and 0.8 percent, respectively.

All non-parametric terms in the three models make significant contributions, except for *extent of markets* in output commercialization, and *travel time* to consumer market in input commercialization (Table 1). All of the predictors display non-linear behavior, supporting the choice of semi-parametric regression. The effects of these determinants are depicted in Figure 6 and Figure 7.

Figure 6: Representation of additive fits to the (logged) output commercialization index



Note: the dashed curves are pointwise 2 x standard- error bands.
Source: Own calculations.

Household size has the negative and non-linear impact on the share of agricultural output marketed and crop specialization. The effect of household size is negative up to a turning point of about 10 members, after which it becomes insignificant as the 2 * standard error bands (approximately 95 percent confidence intervals) become very wide. These results mean that smaller households sell larger shares of their agricultural output and tend to be more diversified.

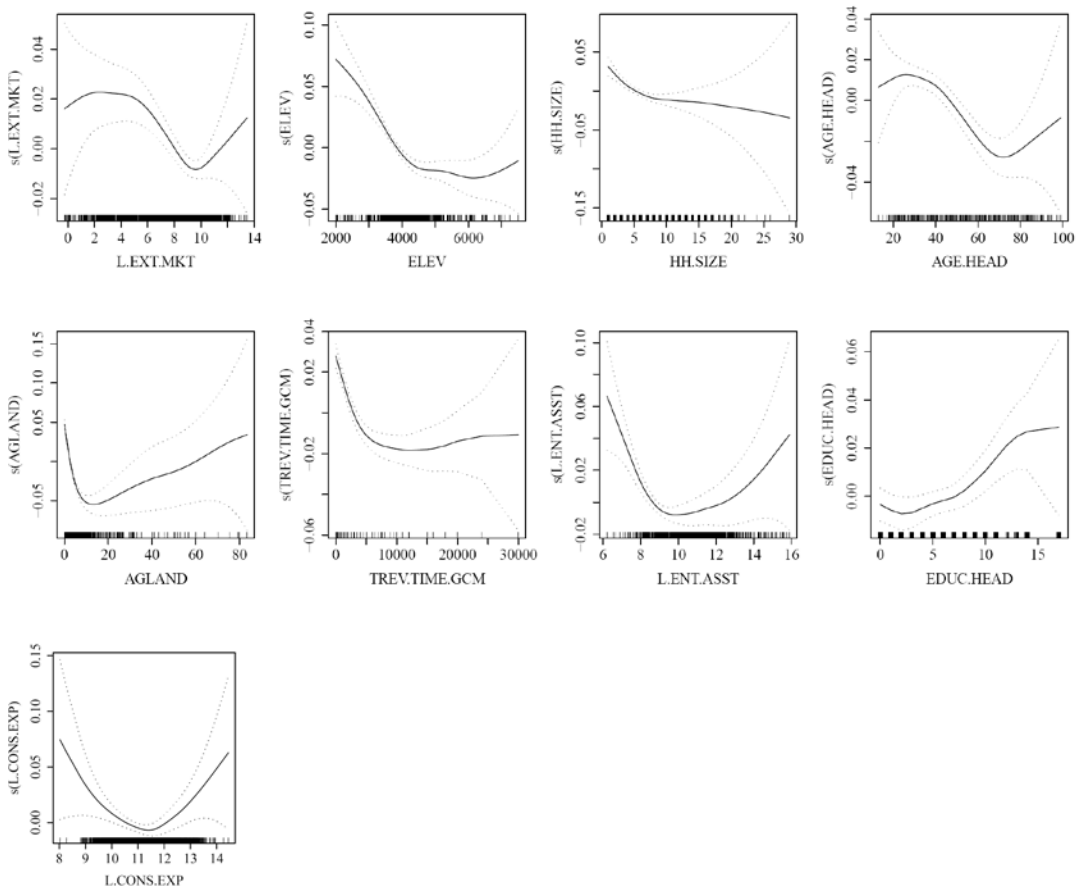
The effect of the *age of the head of the household* is consistent across all models, indicating that younger household heads tend to run more commercial farms. *Better educated farmers* are also more commercial. The effect of schooling years is positive and significant up to a turning point at 10-12 years, i.e. the time for completing advanced studies in secondary school. Afterwards more years of education seem to matter less for commercialization. Better educated households also tend to be more specialized, partially because they have more off-farm opportunities than worse educated farmers and thus have less time for farming.

For both types of commercialization, the effect of *agricultural land* is strongly positive, yet only up to a size of 10 acres. After this point, the effect becomes insignificant. Most of the households in the sample are small; with increasing size, they tend to commercialize and diversify before they begin to specialize (compare Figure 1and Figure 5). The effect of *agricultural and non-agricultural assets* follows a similar pattern as that of *agricultural land*.

The last endogenous determinant of specialization is *consumption expenditure*[9] which has a significant and non-linear impact on household decisions to diversify and specialize. As income grows, most Ugandan households tend to diversify. The process continues to a turning point at which they begin to separate their production and consumption decisions. After this point, households move towards more specialization.

[9] This variable was included only in the Herfindahl index (specialization) model, following the practice in the literature.

Figure 7: Representation of additive fits to the (logged) Herfindahl index



Note: the dashed curves are pointwise 2 x standard- error bands.
Source: Own calculations.

The *travel time to consumer market* is a significant determinant of the commercialization. Households that are closer to consumer markets (i.e. have better market access) tend to sell more of their produce. The impact is significant within 5 hours of walk (3,000 minutes), or about 20-25 km (at average speed of 4-5 km per hour), becoming insignificant afterwards. Regarding the impact of *travel time* on specialization, areas located further away from the main consumption centers (with the threshold of 1.7 hours of walk) tend to be more diversified.

The *extent of the market* does not significantly influence the level of output commercialization but tends to increase diversification. Access to transport infrastructure and the distance to the market, two infrastructure-proxy variables discussed above, are more important for agricultural commercialization than the size of the urban markets in Uganda.

Elevation plays an important role in commercialization and specialization. As Ruecker *et al*. (2003) write, elevation has a major influence on agro-climatic conditions, soil erosion processes and crop management in highland regions. According to the results of our estimations, the highlands are slightly more commercial than the lowlands, but within both low and highlands, elevation is not a significant determinant of agricultural commercialization. The effect of elevation becomes insignificant at about 5,000 feet or 1,500 meters above the sea level, which is roughly where the highlands start. That means that within the highland areas elevation has no

significant impact on output commercialization. The same conclusion can be drawn for specialization, although the effect becomes insignificant a bit earlier, at slightly above 4,000 feet.

5. Policy Recommendations

To date, commercialization and specialization policy in Uganda has mainly emphasized subsidized technologies through various projects, in particular NAADS. However, our results suggest that this emphasis cannot be expected to be very effective because it does not address the underlying causes of weak market participation, which are the poor access to market and weak human capital. Instead, our results specify that more comprehensive approach is required, which would include investments in better rural infrastructure, more flexible land market, better human capital, functioning technology transfer between research and advisory services, and rural finance tailored to the needs of smallholders. A better investment climate is also required to reduce the costs of doing business to the agro-processing firms and traders and to utilize the exiting 50 percent idle agro-processing capacity in the country (Drew, 2010). This comprehensive approach will have a stronger and more lasting impact on commercialization and specialization.

The largest benefits would come from improving rural connectivity. The Ugandan government has increased investments in roads in recent years, but mainly in national roads. Transport costs in rural areas are estimated to be 3-4 times those incurred on national roads (Zorya, 2009). This gap could be reduced through better maintenance of existing rural roads and the construction of new roads, especially in the North. In addition, spatial allocations should better correlate with agricultural potential, as today more road funds are allocated to areas with lower agricultural potential (Raballand *et al.*, 2009; Zorya *et al.*, 2010). Investing in cross-border connections, especially with Kenya and Sudan, would also help promote trade and market participation of smallholders. In the longer run the revitalization of the railways is a powerful tool to reduce transport costs in Uganda and East Africa as a whole (Teravaninthorn and Raballand, 2009).

Access to markets is a necessary but not a sufficient condition for increased agricultural commercialization in Uganda, however. The current inflexible land market limits land rentals and thus the most cost-efficient way of increasing farm size. Uncertainty over land ownership reduces the incentives to invest in coffee and other productive trees, and in long-term improvements in soil productivity (Deininger and Ali, 2007). Improving the functioning of the land marker is a difficult task in many African countries, but without it Uganda will keep lagging behind, given its rapid population growth and the limited land availability.

Investing in human development is also important. The country has made a significant progress in increasing enrollment in primary schools, but the drop-out rate from these schools is still 50 percent. Investing in rural schools and training farmers through advisory services/NAADS should be a government priority. The success of these advisory services will depend not only on training and advising farmers but also on working closely with research institutions and other partners. A lesson learned from past interventions in Uganda is that weak linkages between agricultural research and advisory services have limited the extension of research outputs to farmers' fields, while poor feedback about farmers' demands and problems have constrained the development or refinement of technologies (World Bank, 2010). These linkages are to be strengthened at various levels but especially at the zonal level through the Zonal Agricultural Research and Development Institutes and the district and sub-county-level technical specialists.

Improving the farmers' access to finance is also required to promote commercialization. Banks are unlikely to increase lending to smallholders of their own accord, so innovative schemes must be developed. Savings and credit cooperatives (SACCOs) need to be included in the legal banking framework and supervision mechanisms. In addition, linking farmers to markets through outgrower schemes can be pursued through the planned Commercialization Challenge Fund under NAADS. Private-public partnerships can be developed to provide services to farmers. The funds for these activities are budgeted under the newly prepared Agricultural Technology and Agribusiness Advisory Service Project, and should be implemented as early as possible.

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Annex I

Table 2: Summary statistics of the data

	mean	sd	min	max
Transport Infrastructure	0.92	0.27	0.00	1.00
Size of the Household	6.22	3.21	1.00	29.00
Elevation	4,059.99	762.12	1,998.00	7,506.00
Log. Extend of Markets	8.33	2.16	-0.09	13.48
Output Commercialization	0.25	0.20	0.00	0.69
Age of the HH Head	43.89	15.77	13.00	99.00
Agricultural Cultivated Land	3.84	5.88	0.02	83.50
Travel Time to Common Consumer Market	5,418.41	5,416.57	0.00	3,0000.00
Sex of HH Head	0.74	0.44	0.00	1.00
Financial Infrastructure	0.05	0.22	0.00	1.00
Off-Farm Employment	0.36	0.48	0.00	1.00
Education of the HH Head	5.07	3.84	0.00	17.00
Log HH Agricultural and Non-Agricultural Assets	9.32	1.29	6.22	15.90
Input Commercialization	0.20	0.32	0.00	3.89
Log Consumption Expenditure	11.01	0.79	8.02	14.45

Source: own calculations.