The determinants and extent of crop diversification among smallholder farmers

A case study of Southern Province, Zambia

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ABSTRACT
Agriculture is vital to Zambia’s economic development and is a mainstay for the livelihoods of a large proportion of the population. Agricultural production is mainly dependent on rain-fed hoe cultivation with maize as the principal staple food crop. About 18 percent of national maize production comes from Zambia’s Southern province. In order to improve food security and minimise risks associated with heavy dependence on maize, the government of Zambia has been promoting crop diversification. This study analyzed the determinants of crop diversification as well as the factors influencing the extent of crop diversification by smallholder farmers in Southern province. The study used secondary data from the Central Statistical Office of Zambia. Results from a double-hurdle model analysis indicates that landholding size, fertilizer quantity, distance to market, and the type of tillage mechanism adopted have a strong influence on whether a farmer practices crop diversification. Our findings have important implications for policies that are designed to enhance crop diversification. In particular, our results suggest the need for government to consider undertaking policies that will enhance farmers’ access to and control over land, that will provide farmers with improved access to agricultural implements like ploughs, and that will bring trading markets closer to farmers.

Keywords: crop diversification, double-hurdle model, Zambia.

1. INTRODUCTION
Agriculture is a mainstay for the livelihoods of a large proportion of the population, an important sector of Zambia’s economy, and generates approximately 10 percent of the country’s foreign exchange earnings (Chiwele 2010). Collectively, crop agriculture, livestock, fisheries, and forestry account for about 20 percent of Zambia’s Gross Domestic Product (GDP) and some 35 percent of earnings from non-traditional exports (ZDA 2011). There is a consensus throughout the research literature that Zambia’s large potential in agriculture has not yet been fully exploited. If well managed, the sector could contribute to substantial improvements in GDP, employment, and tax revenue (FAO Zambia 2005). It is in this regard that the Zambian government seeks to position the agricultural sector as one of the driving forces for the economic growth that is required to reduce poverty in the country (Gibson 2005).

The agricultural sector in Zambia can be disaggregated into three categories; commercial, medium, and small scale. Commercial farmers cultivate areas of 20 hectares and above and are characterized by extensive mechanization, use of modern technology and management, and the rearing of exotic breeds of livestock. They also rely extensively on hired labor. However, nearly two-thirds of agricultural land and a large share of the national herd are held by smallholder farmers. The smallholder farmers are classified as either small-scale or medium-scale. The former cultivate land areas of less than 5 hectares, while medium-scale farmers are those who cultivate areas between 5 and 20 hectares. The majority of smallholder farmers rely on rain-fed hoe cultivation and the use of unpaid family labor and focus much of their crop production on maize. Their production also is characterized by the low use of modern inputs (Chomba, 2004).

Following several drought cycles, in 2004 the Government of Zambia, through the Ministry of Agriculture and Cooperatives, introduced a programme to promote crop diversification. Crop diversification is defined as the growing of two or more crops on a piece of land by a farmer. The crops considered in the diversification programme included cassava, sweet potato, groundnut, sunflower, soya bean, Bambara nut, velvet bean, cashew nut, kenaf, paprika, Irish potato and cowpea. The programme was implemented with the objective of increasing the food security and nutrition status of farm households. It was anticipated that this, in turn, would enhance the living standards of farm households, while offering various cropping alternatives to farmers, as opposed to their relying on a single crop, maize. Among the additional advantages to the farm household of growing more than one crop is an opportunity to mitigate risks associated with crop-specific failure due to adverse weather conditions, pests, and diseases (MACO 2004).

1.1 Concepts of crop diversification
Crop diversification is regarded as one sub-set of a large matrix of production options in the cropping sector. From an economic point of view, diversification can be examined from two analytical viewpoints: first, as a problem of determining, given a set of prices, the optimal crop mix on a production possibility frontier; and second, as a mechanism for incorporating risk aversion into a farmer’s decision making process in which crop specialisation may lead to highly unstable income due to variance in output, production, or price for the particular crop (Hazell 1987). Diversification is seen as having two main properties. First, it expands the production possibility set or area allocation frontier for a farmer, thereby increasing opportunities for income generation and employment creation. Second, it reduces the risk of having all of one’s eggs in a basket with one crop only or a few crops with potentially high covariance risk (Samuelson 1967).

In the context of agriculture, diversification is regarded as the re-allocation of some of a farm’s productive resources, such as land, capital, labour, and farm equipment, into new farm activities. Crop diversification is usually viewed as a shift from
traditionally grown, less profitable crops to newer, more profitable crops. It is also a strategy that is used to maximize the use of land, water, and other resources for the overall agricultural development in a country. It provides farmers with feasible options to grow different crops on their land. Therefore, a farmer’s decision to diversify is considered a major economic decision that has a strong bearing on the farmer’s income level and food security (Pope and Prescott 1980).

There are many factors that may lead a farm household to diversify its cropping enterprises. These include the need to reduce risk, responding to changing consumer demands or changes in government policy, responding to external shocks, and, more recently, as a coping strategy to the challenges arising from climate change. Crop diversification provides a broader choice in the production of a variety of crops in a given area and also lessens the risk of crop failure. It also can offer comparatively higher net returns from crops, higher net returns per unit of labour, optimization of resource use, and higher land utilization efficiency (Ashfaq et al. 2008).

1.2 Objectives of the study

The objectives of the study were to:

a) Compare the demographic and socio-economic characteristics of farmers who produce a diversified crop mix with those who do not.

b) Identify the major determinants that influence farmer’s decisions to diversify in crop production.

c) Determine the factors influencing the extent of crop diversification by smallholder farmers.

1.3 Literature on crop diversification

Numerous studies have been done on the determinants of crop diversification. A study on the nature and extent of crop diversification in Karnataka state in India done by Saraswati et al. (2011) revealed that crop diversification was determined by a number of infrastructural and technological factors. Their findings suggested that the creation of basic infrastructural facilities, such as sustained supply of irrigation water, markets, fertilizer availability, proper roads, and transportation, was an essential pre-requisite for creating enabling conditions for crop diversification. The study found that crop diversification had an important positive effect on production. This study employed secondary data for the period 1982 to 2008. The data was analyzed using the Composite Entropy Index (CEI) and multiple linear regression analysis. The CEI for different crop groups showed that almost all the crop groups had a higher crop diversification index during the post-World Trade Organization (WTO) period (1996 to 2008) than during pre-WTO period (1982 to 1995) period, except for oilseeds and vegetable crops, suggesting that broader policy issues have a bearing on the degree to which farmers diversify their crop production (Saraswati et al., 2011).

Another study on crop diversification carried out in Pakistan by Ashfaq et al. (2008) found that crop diversification levels were determined by the size of landholding, the age, education level, farming experience, and off-farm income of the farmer, the distance of the farm from the main road and from the main market, and farm machinery ownership. In their study an entropy index was used to measure diversification and, thereafter, a multiple regression model was used to determine factors affecting crop diversification.

A study by Bhattacharyya (2008) on crop diversification as a search for alternative income for farmers in the state of West Bengal in India showed that the agricultural sector there was gradually diversifying towards high value commodities, such as fruits, vegetables, and flowers. The research revealed that most crop diversification came through the individual efforts of small farmers, with little support from government, as government policies mainly emphasized cereal-based production for household food security. The study used the Simpson Diversity Index as a dependent variable in a regression equation so as to determine the separate effects of each individual explanatory variable on crop diversification. The major determinant of diversification was a demand-side factor that had induced farmers to shift towards production of high value crops. In addition, road development and increased technology adoption were key determinants in this respect. Crop diversification was more prominent in rain-fed areas than in irrigated zones. The rain-fed areas were seen as becoming the hub of non-cereals due to the low water requirements of these crops and the abundant labour supply in rain-fed areas. As the cost of cultivation of fruits, vegetables, and flowers was relatively low, the high value crops were becoming popular among small farmers who could not afford high agricultural-related investment costs. However, the decisions to diversify the crops farmers produced in West Bengal were affected by a lack of proper institutional support. Farmers required from government proper financial resources, guidance, encouragement, and training in new production techniques (particularly for creating crop nurseries) to attract farmers towards high value crop cultivation.

A study by Ibrahim et al. (2009) on crop and income diversification among farming households in a rural area of north-central Nigeria reported that crop and income diversification were strategies that were essential for reducing rural poverty and raising income. The study used the Simpson Index of Diversification and Ordinary Least Squares regression
approaches for data analysis. The study identified the key determinants of income diversification as the number of adults above 60 years old in a household, number of children less than 12 years old, distance from local market, and availability of electricity in the household, while the determinants of crop diversification were age of household head, level of education of the household head, number of extension visits the farmer received, availability of tractor hiring services, and returns from crop production.

A study by Simwambana (2007) in the Southern province of Zambia revealed that most farmers did not diversify their crop production. This study used common rapid appraisal methods and had its own weaknesses because it focused only on cassava and sweet potato, ignoring crops like groundnut and sunflower, which are also important crops in the diversification programme. Furthermore, the study limited itself to three districts out of the eleven in the province. Despite the Zambian government having a policy programme with regard to crop diversification, this study showed that crop diversification is low, with the agriculture sector being highly undiversified, and maize being the main staple crop (JCTR 2008).

Kankwamba, et al. (2012) conducted a study on the determinants of crop diversification in Malawi which used the Herfindahl Index. The agricultural sector in Malawi is highly undiversified, with maize and tobacco being the dominant staple and export crops, respectively. Despite this, the government had since the 2005/06 cropping season implemented the Farm Input Subsidy Program aimed primarily at increasing maize productivity and output. They found that, although crop diversification had deteriorated nationally and regionally, beneficiaries of the subsidy program had become more diversified in their cropping practices. Their study concluded that, while various policies in Malawi all encourage agricultural diversification in broad terms, there was a lack of strategic thinking around how exactly it was to be achieved, and more importantly, how crop diversification could be promoted among different types of farmers with the aim of contributing to economic growth, risk mitigation, and nutrition security.

The economic literature identifies a number of analytical approaches that can be used to determine the nature and extent of crop diversification. Saraswati et al. (2011) employed a multiple linear regression analysis, whereas Ibrahim et al. (2009) adopted a linear regression approach. The problem with linear regression is that one cannot be sure about the underlying causal mechanism between the dependent variable and the explanatory variables, but can only ascertain that a relationship exists. In other words, linear regression analysis does not prove causality (Wan 2012). The double-hurdle model is appropriate, as it allows for separate estimation of the probability of participation in crop diversification and, if a farmer is diversifying production, the extent of diversification (Cragg 1971). In addition, the Herfindahl Index and the Crop Diversification Index can be used to understand the determinants of diversification for those farmers who diversified their crops.

As far as the research literature is concerned and to our knowledge, no study has been conducted in Zambia with regard to the determinants and extent of crop diversification among farmers in Southern Province. Therefore, the purpose of this study was to examine these issues in the Zambian context using a double-hurdle model to analyze the determinants and the factors influencing the extent to which farmers diversified their crop production.

2. METHODOLOGY

2.1 Theoretical framework

The analytical model used for this study draws upon the theory of crop diversification among smallholder farmers. The fundamental assumption is that a farmer’s decision on whether to diversify or not is based upon utility maximization (Rahm and Huffman 1984). The expression $U(W_i, L_i)$ is a non-observable underlying utility function, which ranks the preference of the $i^{th}$ farmer for the $j^{th}$ diversification process ($j = 0, 1$: where $0 =$ no diversification and $1 =$ diversification). Thus, the utility derived from crop diversification depends on $W_i$, which is a vector of farm- and farmer-specific attributes of the diversifier and $L$, which is a vector of the attributes associated with crop diversification. Although the utility function is unobserved, the relation between the utility derivable from the $j^{th}$ diversification process is postulated to be a function of the vector of observed farm, farmer, and crop diversification specific characteristics and a disturbance term having a zero mean:

$$U_{ij} = \alpha_j F_i(W_i, L_i) + e_{ij} \quad j = 0, 1; i=0, 1, \ldots n$$

Since the utilities $U_{ij}$ are random, the $i^{th}$ farmer will select the alternative $j = 1$ if $U_{i1} > U_{i0}$ or if the non-observable (latent) random variable $y^* = U_{i1} - U_{i0} > 0$. The probability that $Y_i$ equals one (i.e., that the farmer practices crop diversification) is a function of the explanatory variables:
\[ P_i = P_i(Y_i = 1) = P_i(U_{1i} > U_{0i}) \]
\[ = P_i[\alpha_i F_i(W_i, L_i) + e_{1i} > \alpha_0 F_i(W_i, L_i) + e_{0i}] \]
\[ = P_i[e_{1i} - e_{0i} > F_i(W_i, L_i)(\alpha_1 - \alpha_0)] \]
\[ = P_i(\mu_i > -F_i(W_i, L_i)\beta) \]
\[ = F_i(X_i\beta) \quad (2) \]

Where \( X \) is the \( n \times k \) matrix of the explanatory variables and \( \beta \) is a \( k \times 1 \) vector of parameters to be estimated, \( P_r(.) \) is the probability function, \( \mu_i \) is the random error term, and \( F_i(X, \beta) \) is the cumulative distribution function for \( \mu_i \) evaluated at \( X, \beta \). The probability that a farmer will diversify in crop production is a function of the vector of explanatory variables and of the unknown parameters and error term. Equation (2) cannot be estimated directly without knowing the form of \( F \). It is the distribution of \( \mu_i \) that determines the distribution of \( F \).

The functional form of \( F \) is specified with a Cragg’s Tobit alternative or a double-hurdle model. A double-hurdle model is used to assess the determinants of crop diversification as well as the factors influencing the extent of crop diversification by smallholder farmers. Since some farmers did not diversify, the dependent variable has a lot of zeroes, resulting in a corner-solution outcome. In such a situation, ordinary least square regression cannot be used since its outcome generates inconsistent and biased parameter estimates (Wan, 2012). Instead, the Tobit model can be used, but is very restrictive given that it simultaneously estimate the determinants of the probability of participation in crop diversification and the extent of diversification (Keelan, et al. 2006).

The Tobit model also assumes that the coefficients on the probability and extent are equal, and this assumption may not always be reasonable (Lin and Schmidt 1984). Consequently, we use a double-hurdle model, which is a two-stage estimation approach, to overcome the Tobit restriction. The double-hurdle allows for separate estimation of the probability of participation and the extent of diversification (Cragg 1971). The first stage of the model is a probit which allows for a separate estimation of the probability of participation in crop diversification, while the second stage examines the decision by the farmer with regard to the extent of crop diversification.

\[ y_{it}^* = w_{it} \alpha + v_i \quad \text{Participation decision} \quad (3) \]
\[ y_{it}^{*2} = x_{it} \beta + \mu_i \quad \text{Extent decision} \quad (4) \]
\[ y_{it} = x_{it} \beta + \mu_i, \text{if } y_{it}^* > 0 \text{ and } y_{it}^{*2} > 0 \quad (5) \]
\[ y_{it} = 0, \text{ otherwise} \quad (6) \]

Where \( y_{it}^* \) is a latent variable describing the farmers decision to participate in crop diversification, \( y_{it}^{*2} \) is a latent variable describing the extent of crop diversification, \( y_{it} \) is the observed dependent variable (farmer’s extent to diversify), \( w_{it} \) is a vector of variables explaining the participation decision, \( x_{it} \) is a vector of variables explaining the extent decision, \( v_i \) and \( v_{it} \) and \( \mu_{it} \) are the respective error terms assumed to be independent and distributed as \( v_i \sim N(0,1) \) and \( \mu_{it} \sim N(0, \sigma^2) \).

### 2.2 Specification of the empirical model

We employ the Crop Diversification (CDI) index in determining crop diversification for the particular crops of interest. The CDI is obtained by subtracting the Herfindahl index (HI) from one. The CDI is an index of concentration and has a direct relationship with diversification such that a zero value indicates specialization and a value greater than zero signifies crop diversification. Thus, it becomes easy to identify those farmers that are practicing crop diversification.

The CDI index is calculated as follows:

\[ P_i = \frac{A_i}{\sum_{i=1}^{n} A_i} \]
where,
\[ P_i = \text{proportion of } i^{th} \text{ crop} \]
\[ A_i = \text{area under } i^{th} \text{ crop} \]
\[ \sum_{i=1}^{n} A_i = \text{Total cropped area} \]
\[ i = 1, 2, 3, \ldots, n \text{ (number of crops)} \quad (7) \]
HI = \sum_{i=1}^{n} P_i^2 \quad \text{Herfindahl index} \quad (8)

CDI = 1 - \sum_{i=1}^{n} P_i^2 = 1 - HI \quad \text{Crop diversification index} \quad (9)

After that, the Cragg’s Tobit alternative model is applied in estimating the determinants of the probability of a farmer practicing crop diversification and the determinants of the extent of crop diversification. The empirical model is specified as follows:

Stage 1: \( P(D_i = 1|X_i) = w_i \alpha + v_i \) \quad \text{Participation decision} \quad (10)
Stage 2: \( Y_i = x_i \beta + \mu_i \) \quad \text{Extent decision} \quad (11)

where \( D_i \) takes the value of 1 if a farmer practiced crop diversification; \( Y_i \) is the crop diversification index; \( w_i \) and \( x_i \) are the vectors of explanatory variables assumed to influence participation and extent of crop diversification, respectively, and are the same for both stages; \( \alpha \) is the vector of coefficients associated with \( w_i \) in the first stage; and \( \beta \) is the vector of coefficients associated with \( x_i \) in the second stage.

Descriptive statistics help in identifying the significant differentiating socio-economic characteristics of the two groups (diversifiers and the non-diversifiers). The statistical significance of the descriptive variables is tested using Chi-square and t-tests for dummy and continuous variables, respectively. By applying descriptive statistics, one can describe, compare, and contrast different categories of sample units (diversifiers and non-diversifiers) with respect to the desired characteristics.

2.3 Data

This study uses secondary data from the Central Statistical Office of Zambia (CSO). The CSO keeps information for most of the government departments of the country and conducts various research projects and surveys. The data for this study is based on the Crop Forecast Survey (CFS) that CSO conducts annually. The survey is representative at the national level. This study uses cross sectional data from this survey for the year 2010. The purpose of the Crop Forecast Survey is to obtain data for the current agricultural season. In general, the data obtained every year usually relate to area planted to crops, expected or realized production, quantity and variety of seed, type of fertilizer used, quantity of crop harvested, crop sales, carryover stocks, crop marketing, and labor costs, among other variables.

2.4 Sample design and sample size

A three-stage sampling procedure is used to select enumeration areas and households for data collection purposes (CSO 2010). At the first stage, Census Supervisory Areas (CSAs) are selected using Probability Proportional to Size (PPS) with the number of agricultural households in the CSA as the measure of size. The CSAs are stratified by district within each province and ordered geographically within each district.

At the second stage, Standard Enumeration Areas (SEAs) are selected using the same procedure described above on the selection of CSAs. The SEA is defined as the segment covered by one enumerator during enumeration. Only one SEA is selected within each sample CSA with PPS for the survey. Once a SEA is selected, an enumerator visits all the households within the SEA and collects a complete listing of basic demographic and agricultural information from all the households in the sampled SEA’s. The information collected then forms the basis for stratifying a household as being agricultural or non-agricultural, with agricultural households being picked for possible selection to be part of the local survey sample.

At the third stage, a count of agricultural households in selected work areas is conducted by listing all agricultural households resident in these areas before selection of sample households for data collection exercise. After a process of stratification, 20 households are then sampled from each SEA using systematic sampling out of a total of between 100 and 150 households per SEA. This represents approximately 20 percent of the total number of agricultural households in a SEA. In the case of Southern province, 94 SEAs were selected for the CFS sample in 2010. However, due to non-response and other challenges with household interviewing, usable data was obtained from 1,555 farmers.

2.5 Study area

Zambia’s Southern province has 11 districts, with Choma as its provincial capital. The Southern Plateau is the center of the province. Southern province has the largest area of farmland of any Zambian province. This study focuses on Southern province as it is an important cropping region for Zambia with maize as the dominant crop grown for commercial use.
cial and subsistence purposes. About 18 percent of national maize production comes from Southern province (Ngoma 2008). Furthermore, this province is a drought-prone area and receives less than 1000 mm of rainfall annually on average. Most of the farmers in the region depend largely on rain-fed hoe cultivation with limited usage of modern inputs for crop production. The government of Zambia has been promoting crop diversification in the Southern province to offer farmers alternative ways of generating income and to improve food security by encouraging farmers to grow other crops in addition to maize. However, few Southern province farmers practice crop diversification (Simwambana 2007).

2.6 Explanatory variables for this study

The following were expected to be the explanatory variables that determine crop diversification. The choice of these variables was based on a review of the literature on the topic and available data. Table 1 presents a summary of these variables.

**Gender of the Household Head:** This is a dummy variable that takes a value of 1 if the household head is male and 0 if female. Male as well as female headed households can choose to diversify or not based on their choice, preferences, and access to resources. Access to resources such as land is an important indicator of welfare among rural farm households and is especially critical for women with no use rights over a parcel of land. In Zambia and elsewhere in the region, women rarely own or have control over land and other assets (Shezongo 2005). The inequality that exists in accessing and having resources between males and females determines how each household will respond to diversification. Thus the nature of the relationship of this variable is expected to vary.

**Age of Household Head** is a continuous variable and is one of the factors that affect production decisions on the part of the farmer. Elderly farmers look at farming as just a way of life, whereas young farmers may be more inclined to look at farming as a business opportunity for family sustenance (FAO 2012). In this study, it is expected that elderly farmers will not diversify, while younger farmers will seek to diversify. Therefore, it is expected that the variable will be negatively associate with crop diversification.

**Household Size:** The size of the household is expected to be positively related with crop diversification. The larger the household size, the more likely that it will be able to diversify so as to increase its food production levels. Previous studies also support this hypothesis (Weiss and Briglauer 2000; Benin et al. 2004).

**Level of Education of Household Head:** It is argued that educated people can understand agricultural instructions easily and are better able to apply skills imparted to them, unlike the uneducated. It is therefore expected that this variable will positively influence crop diversification. Previous findings by Ibrahim et al. (2009) indicate a positive relationship between education level and crop diversification.

**Size of Landholding:** This is a continuous variable referring to the total area of arable farmland that a farmer owns. The amount of land a farmer has available plays a crucial role in determining how many crops a farmer can produce. Previous findings shows that crop diversification is associated with larger farms (Weiss and Briglauer 2000; Benin et al. 2004). Therefore, it is expected that the variable will be positively associated with crop diversification.

**Number of Fields or Farm Plots:** This refers to the total number of fields or farm plots that a farmer has. This variable is continuous and it is expected to influence crop diversification in a positive way. According to Benin et al. (2004), the more farm plots a farmer has, the more he or she is able to diversify.

**Hired Labour:** In instances where farming households do not have enough domestic labour, hired labour is used as a supplement. In most cases, hired labour is sourced within the community, with wages being paid either in kind or in cash. Culas (n.d.) found that a greater use of both family and hired labour is associated with increased crop diversification. As a result, this variable is expected to positively influence crop diversification.

**Tillage Time:** refers to the relative time period during which tillage is done, either during or before the rainy season. Tillage done during the rainy season gives farmers a surety that the rains will be there for their crops. A study in Malawi (Kankwamba, et al. 2012) found that rainfall determines crop diversification. As a result, this variable is expected to positively influence crop diversification.

**Plough Tillage:** This refers to land tilling using a plough. The farmers who use a plough for tilling their land are more likely to diversify because ploughing involves a larger area to be brought into crop production. Studies indicates that there is a positive relationship between possession of farm implements and machinery by a farmer and diversification (Mesfin, et al. 2011). As a result, it is expected that this variable will be positively associated with crop diversification.

**Fertilizer Quantity:** Fertilizer is an important input because without it, most crops in the Southern province do not produce well, expect for leguminous crops. As a result, fertilizer usage by farmers on their crops has continued being an
essential practice to enhance their crop production. Kumar and Chattopadhyay (2010) show that the quantities of fertilizer obtained by farmers is positively associated with crop diversification. Thus, this variable is expected to positively influence crop diversification.

**Distance to the Market**: Distance to the market is an indicator of physical access to markets and organized trade, as well as proximity to economic resources. The nearer to the market the farmer is, the easier it becomes for him or her to diversify and to take produce to market. Studies on diversification highlight the importance of proximity to main roads and markets for development of other farm enterprises (Benin et al. 2004). However, in some instances, farmers located farther away from markets or main roads, are found to diversify in order to meet their broad subsistence and nutritional needs (Kankwamba, et al. 2012). Hence, the nature of the association of this variable with crop diversification is indeterminate and could be negatively or positively associated.

### Table 1—Description of variables used in the study

<table>
<thead>
<tr>
<th>Variable</th>
<th>Type</th>
<th>Description</th>
<th>Expected relationship to crop diversification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Dummy</td>
<td>Gender of head of household (male = 1)</td>
<td>+/-</td>
</tr>
<tr>
<td>Age</td>
<td>Continuous</td>
<td>Age of household head (years)</td>
<td>-</td>
</tr>
<tr>
<td>Household size</td>
<td>Continuous</td>
<td>Number of people in household (proxy for labor supply)</td>
<td>+</td>
</tr>
<tr>
<td>Education</td>
<td>Dummy</td>
<td>Whether household head attended school (primary and above=1)</td>
<td>+</td>
</tr>
<tr>
<td>Size of land</td>
<td>Continuous</td>
<td>All land operated for agricultural purposes and owned by farmer (hectares)</td>
<td>+</td>
</tr>
<tr>
<td>Number of fields</td>
<td>Continuous</td>
<td>Total number of fields or farm plots that a farmer has (number)</td>
<td>+</td>
</tr>
<tr>
<td>Hired labor</td>
<td>Continuous</td>
<td>Number of people employed for wages during cropping season (person-days)</td>
<td>+</td>
</tr>
<tr>
<td>Tillage time</td>
<td>Dummy</td>
<td>Whether tillage was done during or before the rainy season (during = 1)</td>
<td>+</td>
</tr>
<tr>
<td>Plough tillage</td>
<td>Dummy</td>
<td>Land preparation using a plough (used a plough=1)</td>
<td>+</td>
</tr>
<tr>
<td>Fertilizer quantity</td>
<td>Continuous</td>
<td>Amount of fertilizer obtained for crop production (kg)</td>
<td>+</td>
</tr>
<tr>
<td>Distance</td>
<td>Continuous</td>
<td>Distance from homestead to nearest market (km)</td>
<td>+/-</td>
</tr>
</tbody>
</table>

### 3. RESULTS AND DISCUSSIONS

This section presents and discusses the study findings. It starts with a discussion on the descriptive analysis to give a picture of the characteristics of diversifier and non-diversifier farmers, socio-economic, demographic, and institutional characteristics are among them. Thereafter, the econometric analysis is described through the double-hurdle model which produced estimates on the determinants and the factors influencing the extent of crop diversification, thereby achieving the study objectives.

### Table 2—Summary of demographic and socio-economic characteristics of farmers

<table>
<thead>
<tr>
<th></th>
<th>Diversifiers, %</th>
<th>Non-diversifiers, %</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male head of household</td>
<td>99.1</td>
<td>98.3</td>
<td>0.215</td>
</tr>
<tr>
<td>Attended school, head of household</td>
<td>49.1</td>
<td>50.2</td>
<td>0.690</td>
</tr>
<tr>
<td>Used plough for tillage</td>
<td>87.0</td>
<td>81.5</td>
<td>0.004 ***</td>
</tr>
<tr>
<td>Prepared land during (rather than before) rainy season</td>
<td>18.4</td>
<td>11.4</td>
<td>0.001 ***</td>
</tr>
<tr>
<td>Age of household head, yr.</td>
<td>33.6</td>
<td>33.5</td>
<td>0.826</td>
</tr>
<tr>
<td>Household size</td>
<td>6.7</td>
<td>6.6</td>
<td>0.571</td>
</tr>
<tr>
<td>Distance to market, km</td>
<td>10.5</td>
<td>8.5</td>
<td>0.000 ***</td>
</tr>
<tr>
<td>Landholding size, ha</td>
<td>9.7</td>
<td>7.4</td>
<td>0.000 ***</td>
</tr>
<tr>
<td>Fields, number</td>
<td>4.0</td>
<td>3.9</td>
<td>0.042 **</td>
</tr>
<tr>
<td>Fertilizer quantity used, kg</td>
<td>41.7</td>
<td>29.2</td>
<td>0.000 ***</td>
</tr>
<tr>
<td>Hired laborers, number</td>
<td>1.9</td>
<td>1.8</td>
<td>0.337</td>
</tr>
</tbody>
</table>

Note: Significance level: *** (p ≤ 0.01); ** (p ≤ 0.05); * (p ≤ 0.10)
Source: Author’s calculations based on CSO data (2010)
From Table 2, we find that the difference in the proportion of male-headed households between diversifiers and non-diversifiers was not statistically significant. Similarly, regarding education, there was no significant difference in the proportion of heads of farming households that had ever attended school between diversifiers and non-diversifiers. However, a positive association with crop diversification was found for whether a plough was used for tillage and whether tillage was done during, rather than before, the rainy season. A significantly larger proportion of diversifiers than non-diversifiers used a plough as their mode of tillage and did their tillage during the rainy season (although most farmers, both diversifiers than non-diversifiers prepared their land before the rainy season). There is a statistically significant difference between diversifiers and non-diversifiers in the mean distance to the market, size of land holding, number of fields, and fertilizer quantity used – diversifiers are located farther from the nearest market, have larger landholdings and more fields, and use more fertilizer.

Results of the double-hurdle model (Table 3) shows that whether a farmer diversifies his or her crop production is dependent on the size of the landholding, the quantity of fertilizer used, distance from the farm to the market, and whether a plough is used for tillage. As for the extent of crop diversification, it is significantly influenced by fertilizer quantity used and distance to the market. For all significant determinants in both model, only direct positive relationships are observed. Significant negative relationships are only seen in the coefficients for some of the district dummy variables included in the model.

Table 3—Determinants and extent of crop diversification by smallholder farmers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Probability of engaging in crop diversification</th>
<th>Total crops grown, if engage in crop diversification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (male = 1)</td>
<td>0.087</td>
<td>-0.009</td>
</tr>
<tr>
<td>Age of household head (in years)</td>
<td>0.034</td>
<td>-0.024</td>
</tr>
<tr>
<td>Household size (labor supply proxy)</td>
<td>-0.012</td>
<td>-0.000</td>
</tr>
<tr>
<td>Number of fields (ha)</td>
<td>-0.037</td>
<td>-0.003</td>
</tr>
<tr>
<td>Plough tillage (used a plough=1)</td>
<td>0.032 ***</td>
<td>0.036 ***</td>
</tr>
<tr>
<td>Tillage time (during rainy season=1)</td>
<td>0.013</td>
<td>0.010</td>
</tr>
<tr>
<td>Size of land (ha)</td>
<td>0.011 ***</td>
<td>0.012</td>
</tr>
<tr>
<td>Distance to the main market (km)</td>
<td>0.027 ***</td>
<td>0.018 ***</td>
</tr>
<tr>
<td>Education (primary and above=1)</td>
<td>-0.139</td>
<td>-0.006</td>
</tr>
<tr>
<td>Hired labor (person-days)</td>
<td>-0.232</td>
<td>-0.038</td>
</tr>
<tr>
<td>Fertilizer quantity (kg)</td>
<td>0.099 ***</td>
<td>0.120 **</td>
</tr>
<tr>
<td><strong>District dummy variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Choma (1=yes)</td>
<td>0.213</td>
<td>-0.089 ***</td>
</tr>
<tr>
<td>Gwembe (1=yes)</td>
<td>0.022</td>
<td>-0.031</td>
</tr>
<tr>
<td>Ittezi Tezhi (1=yes)</td>
<td>0.954 ***</td>
<td>0.058</td>
</tr>
<tr>
<td>Kalomo (1=yes)</td>
<td>0.599 ***</td>
<td>-0.002 ***</td>
</tr>
<tr>
<td>Kazungula (1=yes)</td>
<td>-0.406 *</td>
<td>-0.142 ***</td>
</tr>
<tr>
<td>Livingstone (1=yes)</td>
<td>-0.786 ***</td>
<td>-0.153 ***</td>
</tr>
<tr>
<td>Mazabuka (1=yes)</td>
<td>-0.028</td>
<td>-0.038 *</td>
</tr>
<tr>
<td>Monze (1=yes)</td>
<td>0.334 *</td>
<td>-0.013 **</td>
</tr>
<tr>
<td>Namwala (1=yes)</td>
<td>0.696 ***</td>
<td>0.036 *</td>
</tr>
<tr>
<td>Siavonga (1=yes)</td>
<td>1.854</td>
<td>0.199</td>
</tr>
<tr>
<td><strong>Number of observations</strong></td>
<td>1,555</td>
<td>1,073</td>
</tr>
<tr>
<td><strong>Wald (χ²)</strong></td>
<td>374.0</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Prob &gt; χ²</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Log Likelihood</strong></td>
<td>-182.1</td>
<td></td>
</tr>
</tbody>
</table>

Note: Significance level: *** (p ≤ 0.01); (p ≤ 0.05); ** (p ≤ 0.10)*
Source: Author’s calculations based on CSO data (2010)

We found no multicollinearity between any two or more explanatory variables in our study. When multicollinearity between explanatory variables is present, it is quite difficult to separate the independent effect of each parameter estimate on the dependent variable. If multicollinearity were found, we would have only limited confidence in any policy prescriptions based on these estimates. Furthermore, all the variables were tested for heteroskedasticity using the Breuch-Pagan test, and heteroskedasticity was not found. Heteroskedasticity is a phenomenon where the variance of the dependent variable is not the same for all independent observations or explanatory variables. If it is detected and is not
taken care of, it leads to high standard errors and inconsistent sample estimates, which may lead to wrong hypothesis testing. In addition, a normality test was done using the kernel density plot of residuals. The kernel density plot provided a fairly smooth curve that closely matched the normal curve, indicating that the normality assumption was not violated. Also, the model specification was carried out using the Ramsey-reset test, and the results revealed that there were no omitted variables in the model.

Size of Landholding

The size of landholding increases the probability that a farmer will engage in crop diversification – there is a direct correlation between size of landholding and crop diversification. This means that an increase in the size of landholding will better enable a farmer to diversify. With the extra landholding, the farmer can decide how many crops to grow based on his or her production decisions. Increasing landholding is possible in the case of Zambia since, of the 58 percent of the total land area suitable for arable farming, only 14 percent is being cultivated currently (MoFNP 2006). Furthermore, study results are in agreement with findings by Ashfaq et al., (2008) in which they reported that the more access to additional land that a farmer has, the more he or she will be able to engage in crop diversification. Our results show that a one percent increase in the size of landholding of a farmer will increase the probability of a farmer producing more than one crop type by 1.1 percent.

Fertilizer quantity

The results show that the quantity of fertilizer used is associated with both a higher probability of a farmer to participate in crop diversification and a greater extent in the diversification in crops grown. A one percent increase in fertilizer quantity used by a farmer will increase the probability of a farmer engaging in crop diversification by 9.9 percent. Furthermore, on average, a one percent increase in fertilizer quantity used will increase the number of crops a farmer will grow by 12 percent. The explanation for this is that increased quantities of fertilizer will provide additional incentive to farmers to diversify since most farmers lack fertilizer, resulting in increased crop failure and poor yields. Furthermore, fertilizer availability enables a farmer to enrich his or her land, which oftentimes is exhausted, thus making it suitable for expanding into the production of a greater variety of crops. Our results concur with findings from India (Kumar and Chattopadhyay 2010; Singh, et al. 2006) and from Malawi (Ndhlouvu 2010), in which it was found that the quantity of fertilizer a farmer uses is a significant determinant of crop diversification.

Plough tillage

Plough tillage significantly determines the probability of a farmer to participate in crop diversification. The probability of a farmer who uses a plough engaging in crop diversification is 3.2 percent higher than for a farmer who does not use a plough. Thus a farmer who uses a plough will more likely diversify his or her crops because tillage using a plough reduces the drudgery of land preparation, reduces the requirement for manual labor, and enables the exploitation of a larger land area compared to using a hand hoe. These study results are in agreement with findings by Mesfin, et al. (2011) in which they reported a positive relationship between possession of farm implements and machinery by a farmer and crop diversification.

Distance to market

Distance to the market significantly determines both the probability of a farmer to participate in crop diversification and the extent of participation. The results entail that a one percent increase in distance to the market significantly increases the probability of a farmer’s participation in crop diversification by 2.7 percent – that is, the further a farmer is from markets, the more likely he or she will diversify crop production. With regards to the extent of crop diversification, on average, a one percent increase in distance to the market will increase the number of crops a farmer will grow by 1.8 percent. The results imply that farming households located farther from the nearest market will diversify for food security due to higher transport costs in accessing market incentives to diversify for commercial purposes. A study by Ibrahim et al. (2009) shows that farming households that are farther away from the main markets face high costs of transportation to get their produce to the market and in such instances, they opt to grow crops only for subsistence purposes.

4. CONCLUSION AND POLICY RECOMMENDATIONS

This study was conducted with the specific objectives of comparing the demographic and socio-economic characteristics of farmers in Southern province of Zambia who produce a diversified crop mix with those who do not, to identify the major determinants that influence farmer’s decisions to diversify in crop production, and to determine the factors influencing the extent of crop diversification by smallholder farmers.
Descriptive statistics were used to assess any differences in the socio-economic characteristics of farmers who have diversified their crop production from non-diversifiers. On average, diversifiers have larger landholdings and use more fertilizer than non-diversifiers. Additionally, a larger proportion of diversifiers used a plough as their mode of tillage than did non-diversifiers and were more likely to do their tillage during the rainy season. Results from the double-hurdle model indicates that the size of landholding, fertilizer quantity, distance to market, and tillage using a plough significantly influence farmers’ probabilities to practice crop diversification. Furthermore, the extent of crop diversification is significantly influenced by the fertilizer quantity and distance to the market.

Our study found that increasing the size of landholding of a farmer by one percent will increase the probability of a farmer to engage in crop diversification by 1.1 percent. The results also indicate that increasing the quantity of fertilizer used by a farmer by one percent will increase the probability of a farmer engaging in crop diversification by 9.9 percent. Moreover, a one percent increase in distance to the market and fertilizer quantity will increase the number of crops a farmer will grow by 1.8 percent and 12 percent, respectively. Furthermore, the results show that farming households further away from the main market are more likely to diversify the crops that they grow, and we suggest that they do not diversify for commercial purposes, but for food security reasons.

The study suggests a number of recommendations for promoting crop diversification among smallholder farmers. First; there is need for the government to consider undertaking policies that will improve farmers’ access to and control over land. Since smallholder farmers are the ones who produce the bulk of the food, improved access to more land will enable farmers to grow more crops, thereby enhancing food and nutrition security status and helping in reducing poverty. Bhattacharyya (2008) shows that land is necessary if Indian farmers are to diversify. Most farmers in India are constrained by insufficient land, such that some of them could not diversify. Also, a study in Ethiopia by Goshu, et al. (2012) indicated that food security status among farming households was mainly increased due to the size of landholding that farmers had, thereby helping in reducing poverty. Furthermore, findings by Ashfaq et al., (2008) reveals that the more access to land a farmer has, the more he or she will be able to engage in crop diversification.

Secondly, as the majority of small-scale farmers are resource poor, have low levels of agriculture production, and are usually food insecure, the government should expand implementation of its policy on mechanizing agriculture production through provision of farm equipment and implements. In order to achieve this, there is a strategy in place of encouraging the involvement of the private sector in the provision of such services (MoFNP 2006). However, the policy has not been implemented (Xu 2009). As this study shows that farmers who till their land using a plough are able to diversify, it is important that the government implements the policy of providing smallholder farmers with agricultural implements like ploughs in order for them to diversify their crop production. One of the benefits of tilling land using a plough is that it significantly decreases the time required for farmers to accomplish farm tasks. For example, using a plough, a farmer can plough in a few hours a field that would take the household an entire day to till using a hoe.

The government should also consider bringing trading markets closer to the farmers given the fact that distance to the market is an indicator of market access, organized trade and proximity to economic resources. Much as the farmers farther away from markets are able to diversify for food security purposes, food security is not everything. Farmers need increased financial resources (cash) to send their children to school, to buy inputs and so on. Therefore, if markets are brought closer, then farmers will diversify for commercial purposes as well. A study by Kumar and Chattopadhyay (2010) revealed that policies directed towards the expansion of infrastructure like road networks, marketing and storage facilities are important preconditions for the diversification of crops for commercial purposes and are crucial in ensuring sustainable income and employment among farmers.
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Acknowledgments

This paper was selected for the Malawi Strategy Support Program (MaSSP) “Bunda Grant Scheme” for 2013/14. Under this capacity building program IFPRI provides financial and supervisory support to students to extract a journal-length article from their MSc theses. The authors would like to thank John Mazunda and Todd Benson for guidance in this regard.