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Smallholders' Livestock Commercialization and Welfare Impacts in Tanzania: Evidence from Tanzania National Panel Survey (NPS)

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Abstract: Using nationally representative Panel survey data from Tanzania, this study estimates the determinants and impact of smallholders' livestock commercialization in the country. Results based on correlated random effect Probit and Tobit models, show that female livestock keepers are more likely to commercialize than their male counterparts, but there is no statistical difference on the magnitude of commercialization intensity. In addition, despite negligible role of education on livestock, commercialization status it is negatively correlated with the intensity of commercialization conditional on commercialization choice. We further document a positive net impact of commercialization on households' welfare, proxied by household expenditure.

1. INTRODUCTION

Agriculture continues to be one of the most important sectors in Tanzania in terms of contribution to GDP and more importantly the share of country's population employed into the sector. When it comes to livestock subsector alone, Tanzania is ranked the third in Africa in terms of the number of livestock it possesses; 25 million cattle, 16.7 million goats, 8 million sheep, 2.4 million pigs, and 36 million chickens. Importantly, 50 per cent of all households in Tanzania own at least one type of livestock. However, despite this endowment, the livestock community in Tanzania has remained among the poorest and the least integrated (in terms of business), raising important research and policy question on drivers for such and best ways to change from status quo. For example, although the national poverty

rate is estimated at 28 per cent; about 60 per cent of the poor are the livestock keeper, majority of whom residing in rural areas.

One important channel that could account for the observed welfare characteristics could be the nature of livestock keeping business among the most rural community. Rural livestock keepers are mainly subsistence-oriented, they participate in livestock market only at the times of cash pressure and not for the purpose of raising lifetime earnings or a source of continuous income generation. This leaves livestock keepers in extreme poverty on material possession, dietary choices and limited means of income. The illiteracy and norms of livestock keepers associated with traditional farming techniques limits the opportunities to make livestock keeping into business and thus expand the economic means (URT, 2013; URT, 2015; NBS, 2012; Covarrubias *et al*.., 2012). Only a small fraction of the Tanzanian livestock keeper commercializes this economic activity. Understanding the drivers for such operational differences and potential welfare implication from the commercialization are of both research and policy relevance.

Despite the potential role of commercialization on welfare of the rural livestock keeping community, little empirical effort has been undertaken to explore the drivers for such suboptimal choices in developing countries, including Tanzania. A huge body of agricultural commercialization literature has mainly focused on crops subsector (see for instance Jaleta, M., 2009), while paying little or no attention to the livestock keeping, a subsector that constitutes of equally significant share of the Tanzanian rural community.

In this study, we explore the key drivers to commercialization by the Tanzanian smallholder livestock keeping households, with a special focus on roles of education and gender, as well as documenting potential welfare implication from such. The study makes use of Tanzania's National Panel Surveys (NPS) along with panel data models (which account for both observable and unobservable individual and time specific effects) to estimate both the determinants and the impacts models. Specifically, we employ the correlated random effect Probit and Tobit regression as well as pooled data double hurdle model to estimate the determinants of participation and intensity of commercialization. Also, a two stage Correlated Random Effect (CRE) model is used to estimate the impact of livestock commercialization on households' welfare. The national panel survey is a rich data set incorporating several questions/variables that can enable the estimations of models needed for this study. Specifically, the data sets constitute of livestock ownership and commercialization questions along with various welfare measure variables (household monthly/weekly expenditures, annual

income, asset ownership and others). This is not to mention several other social economic characteristics including; education, gender and social network status.

Our findings suggest that both education and gender of the household's head have important role to play when it comes to the participation and intensity of livestock commercialization. While education only affects positively the commercialization intensity (but not participation), female headed households are more likely to commercialize (i.e. compared to the male headed households but none is superior on magnitudes of commercialization unless decisions are taken as linked (double hurdle model). We further find that commercialization significantly improves the household's welfare as proxied by total household monthly expenditure. These results are robust to a number of identification methods used in this study.

The rest of the paper is organized as follows; while chapter 2 provides a detailed review of the literature, chapter 3 provides an account of the analytical methodologies used in the study. Results and discussion are presented in chapter 4 while chapter 5 concludes the study and provides policy implications.

2. LITERATURE REVIEW

Theoretically, the decision and intensity of agricultural smallholders' commercialization could be explained by both external and internal factors. External or exogenous factors are those in which a farmer or livestock keeper has no control over them, which include macroeconomic factors such as demographic/population change, technological growth and introduction of new commodities, advancement in infrastructure and market institutions/systems, development of the non-farm sector and the broader economy, increasing labor opportunity costs, trade and sectorial policies affecting prices and other driving forces (von Braun *et al.*. 1991; Pingali and Rosegrant 1995 cited in Jaleta, M. *et al.* 2009; Lubungu, Chapoto, & Tembo, 2012; Tekalign, 2014). Likewise, institutions like property rights and land tenure, cultural and social factors affecting consumption preferences, production and market opportunities and constraints, agro-climatic conditions, and production and market related risks are also considered as external forces (Pender *et al.*. 2006 cited in Jaleta, M. *et al.;* Pender & Alemu, 2007).

However, internal factors are mainly endogenous to the farmer such as smallholder resource endowments including land and other natural capital, labor, physical capital, human capital, etc. These are household specific and considered to be internal determinants. These factors could affect the demand and supply of livestock and livestock products, output and input markets, transaction cost and risk

faced by participant of value chains (Pender, J and Alemu D, 2007;Jaleta *et al*.., 2009; Lubungu *et al*.., 2012).

On the other hand, the effects or impact of livestock smallholders' commercialization can be categorized into three orders. First order effects are much related to income and employment, the second order are on nutrition and health(indirect) depending on the level of income attained and the third order are on macroeconomic and environmental effects which goes beyond household level effects. These order effects are interlinked and thus one influences the other (Jaleta, M. 2009).

Smallholders' commercialization is expected to yield more income or earnings to a household and its members, employment is also expected to increase when people shift from subsistence farming to more specialized production and improves nutrition to the family member because of flexibility of market food purchases over subsistence farming because of its comparative advantage. These effects are contingent on the low level of risk and integrated market so that do not affect household decision on consumption and production due to market price volatility (Kennedy and Cogill 1987; Dorsey 1999 cited in Jaleta, M. *et al.,* 2009;Baisa, 2009; Muricho, 2015; Tekalign, 2014).

A number of studies have tried to empirically explore the determinants and impact of agricultural commercialization albeit in a different context and using different approaches to ours. Jaleta, M *et al.* (2009) in the review of smallholders' commercialization presented a number of empirical studies that have explored on determinants for the decision and extent of smallholders' agricultural commercialization. The authors argue that the determinants of commercialization differ under different circumstances and locality and hence seems to be context specific empirical issue. Importantly, this review study noted that reviewed studies are largely biased to crops commercialization with little assessment on livestock subsector.

Addressing the subsector gap, a study by Ruhangawebare, G. (2010) uses Tobit regression technique to analyze the determinants of cattle commercialization in Uganda. It reveals that cattle keepers responded to seasonal cash demand in market participation, market and information access as well as social characteristics. However, this study had two notable research gaps, first did not consider market participation as a two-decision approach and secondly, did not link commercialization to household welfare.

Another study by Lubungu, M., *et al.* (2012) uses a three-year panel survey of Zambian smallholders to examine the determinants of market participation of

farmers for the three types of livestock namely cattle, pigs and goat. Despite access to panel data, the analysis of the study was limited to the use of simple descriptive statistics and probit model. Their findings indicate that determinants differ across types of livestock and some of suggested factors are not significant, particularly gender. They also noted that the prevalence of selling livestock across waves is minor. Apart from not taking panel data superiority in tackling endogeneity issues, which likely to affect non-linear models, the study also did not link commercialization with households' welfare. Our study employs panel data approaches namely CRE probit and tobit models, which significantly address the endogeneity problems, to investigate contradicting effect of gender on commercialization and link commercialization to household welfare in Tanzania.

The other study on cattle commercialization on livestock by Ndoro, T. *et al.* (2014) in South Africa employed a double hurdle estimation technique to examine determinants of cattle commercialization (decision to commercialize and extent of commercialization). The authors found that the decision to participate and extent of participation in cattle markets is significantly a function of many livelihood drivers such as difference in access to finance, natural capital endowments, and livelihood strategies although the decisions are not simultaneously taken. However, the studies reviewed by the Authors present mixed signs, magnitude and interpretation of the factors determining the level of smallholders' cattle commercialization in South Africa, some with contradicting signs. The role of education and gender received less attention and welfare component was not investigated(Ndoro *et al.*., 2014a).

A study by Kamaghe, A. *et al.* (2014) investigated the livelihood of smallholders' pig farmers in Mbeya and Mbozi district in Mbeya highlands with regards to social, human, physical and natural capital endowments. The study using cross sectional data and much of descriptive statistics concluded that pig farmers in respective locations are for commercial purposes and have contributed to technology scaling up and better standard of living. However, even though the study focused on only one type of livestock, it did not employ causal relationship analysis to investigate the determinants of pigs' commercialization (Kamaghe, Mlozi, Mejer, & Johansen, 2014a).

Other studies conducted in Ethiopia (Negassa and Jabbar, 2008; Berhanu, G. *et al.*., 2015) have demonstrated the determinants of commercialization for both large ruminants (cattle) and small ruminant (goats and sheep) using cross-sectional studies. These studies showed no significant effect of human capital and did not link commercialization to household welfare (Berhanu Gebremedhin, Hoekstra, & Azage Tegegne, 2015).

A study on determinants of livestock commercialization in Rural area of Omario region using pastoral land of Borena zone in Ethiopia by Dagne, G. (2016) investigated using Tobit regression method the significant factors that affect household intensity of commercialization using livestock sales rates as a dependent variable (Dagne, G., 2016). In this study a market participation function only allows one type of livestock at a time, which removes complementarity of livestock types over season in feeding the household. Moreover, the study did not focus on the participation decision of the commercialization process. This study intends to fill both gaps by employing a more comprehensive commercialization index and estimates both participation and intensity decision of commercialization.

3. METHODOLOGY

For the purpose of answering the objectives of this study, several models and approaches were employed. Specifically, we employ Correlated Random Effect (CRE) probit model and Tobit to model the participation decision in the commercialization as well as the intensity of commercialization given the participation decision, respectively. On the other hand, to estimate the causal impact of the livestock commercialization on household welfare, we employ two stage CRE model. Extent of commercialization among livestock smallholders across levels of education and gender was argued based on descriptive statistics using cross tabulations.

3.1. Modeling determinants of commercialization

To investigate the determinants of smallholders' livestock commercialization (study objective two), we employ a non-linear panel model namely correlated random effect (CRE) double hurdle model adopted from Woldeyohanes *et al.*. (2015) mainly for two logical reasons. First, the commercialization process is a two-way decision, that is to decide to go for profit (commercialize) and by how much to go for (extent of commercialization). Second, the commercialization responses are very likely to be encountered by censoring (with many zero responses) due to corner solution optimization which necessitates the choice of the model which takes into consideration such data problems (Woldeyohanes, *et al.*, 2015; Lubungu *et al.*., 2012). Moreover CRE models are designed to address both observed and unobserved heterogeneity (Lubungu *et al.*., 2012; Verbeek, 2004; Wooldridge, 2013).

In a double hurdle model, a household must pass through two hurdles before observing positive market participation or commercialization: first decision to participate and second to what extent to commercialize. A different latent variable is

used to model each decision process; with a probit determining the participation process and a Tobit determining the commercialization level (Eakins, J., 2014).

Double-Hurdle model or crag's alternatives investigates significant factors separately on the decision to commercialize or not, and the extent of participation in commercialization (Verbeek, M., 2004) conditional on crossing the first hurdle. This model combines both probit decision model and Tobit censored regression model. Therefore, double hurdle model is a two way equation framework with both participation and intensity equations for respective decisions (Matshe and Young 2004; Moffatt 2005; Ground and Koch 2008 cited in Ndoro, J. *et al.*, 2014; Woldeyohanes, Heckelei, & Surry, 2015).

The double hurdle model as a non-linear model modified to accommodate panel data analysis present computational and analytical challenges. For the purpose of this study, CRE double hurdle model employed by Woldeyohanes, T. *et al.* (2015) is adopted. The CRE double hurdle model is specified as;

$$C_{it}^{*} = \alpha X_{it} + \theta Z_{it} + c_{1i} + v_{it} \text{ and } C_{it} = \begin{cases} 1 \; if \; C_{it}^{*} > 0 \\ 0 \; otherwise \end{cases} \quad (5)$$

$$HCI^{*}_{it} = \beta X_{it} + \gamma Z_{it} + c_{2i} + \mu_{it} \text{ and } HCI_{it} = \begin{cases} HCI_{it}^{*} \text{ if } HCI_{it}^{*} > 0 \text{ and } C_{it}=1 \\ 0 \; 0 otherwise \end{cases} \text{ for } i=1, \ldots N;\ t = 1, \ldots, T \quad (6)$$

The first equation represents binary (participation) decision and second equation represents extent of commercialization (intensity) decision. The variables, C^{*}_{it} and HCI^{*}_{it} are latent variable with C_{it} and as their respective observable variables. On the other hand, Z_{it} and are both time variant and time invariant controls, which affects the level of commercialization in which Z-controls are key variables of interest namely levels of education and gender. μ_{it} and ν_{it} is random error terms whereas c_{2i} and c_{2i} are time invariant unobserved individual specific effects. The vector θ and γ, are the parameters of key variables of interest to be estimated. Together with their standard errors provides the effects of these variables to household commercialization decisions. The effects of others controls are represented by vectors è and ã in the above equations, respectively. Decisions of other controls are based on reviewed literature and previous studies. In this study, the role of gender and education are given a particular attention.

HCI represents the Household commercialization index in output side of commercialization. In this study as explained in the coming sections, two indices were used, namely market off take rate for real live animal commercialization and value commercialization index here abbreviated as HCIrl and HCIvalue, respectively.

From these equations it is vivid that error term constitutes of time invariant fixed effects in both equations as c_{1i} and c_{2i}. Panel models are superior in tackling these effects, which might cause endogeneity problems in estimation. Although under normal linear random effect models, the assumption postulated is that, these time-invariant individual specific effects are uncorrelated with covariates. If this assumption does not hold then the estimates are biased and/or inconsistent if not controlled. However correlated random effect model allows for the correlation between unobserved heterogeneity and vector of covariates across all time periods by assuming a specific functional form of the unobserved heterogeneity as a linear function of the time average of all-time varying covariates (Woldeyohanes, T. *et al.*, 2015). Therefore, including time average of all time variant explanatory variables we control for time invariant unobserved heterogeneity. CRE model enables us to estimate the effect of time invariant controls on commercialization and then escape incidental problems of non-linear panel models, which would not be possible under fixed models.

For the appropriate interpretation of the results of CRE double hurdle model regarding the nature of the explanatory variables, average partial(marginal)effects of the changes in explanatory variables were calculated to help interpret the results on probability of commercializing and on conditional mean of level of commercializing.

Since double hurdle model do not rely on any choice theory by original formulation (Ndoro *et al.*., 2014; Eakins, J., 2014) the choice of the variables on both equations is always guided by the economic theory although the first hurdle is assumed to be more specific to household (social constraints) and do not related to market characteristics such as prices and market incentives (Eakins, J., 2014). However, in this study, the mathematical model specification was assumed to include the same set of explanatory variables[1].

3.2. Modeling effect of commercialization on household welfare

The effect of smallholders agricultural commercialization on household welfare has been on scholars lens for sometimes now, however as explained earlier in the above sections evidences on livestock commercialization are lacking(Jaleta, Gebremedhin, & Hoekstra, 2009b). This study investigates the impact of smallholders' livestock commercialization on household welfare.

The impact analysis methods including regression methods and welfare comparison strategies like propensity score matching which relies on its ability to

control for observable source endogeneity has presented contradictory evidences of commercialization on household welfare.

Panel data models provide a unique opportunity to tackle both observable and unobservable sources of endogeneity in econometrics estimations. Specifically, panel models have a great advantage of controlling for both observed and unobserved heterogeneity by taking into advantage the panel structure of the data[2]. Using the monetary value commercialization index elaborated below, this study employs two step correlated random effect model to model the impact of smallholders' livestock commercialization on household welfare.

The correlated random effect model as discussed in the above sections allow the correlation between unobserved individual specific effects with regressors and control for it by including in the estimated equation the time average of time varying explanatory variables. The CRE model estimated in this study is specified as:

$$W_{it} = \beta_0 + \beta_1 Z_i + \beta_2 X_{it} + \beta_3 \bar{X}_i + \alpha HCIvalue_{it} + \gamma T_j + \varepsilon_{it} \quad (7)$$

Where $\mathbf{W_{it}}$ is the household welfare indicator, $\boldsymbol{\beta_o}$ *is the* constant term, β_1 is a vector of coefficients for time invariant variables, is the vector of time invariant variables, $\boldsymbol{\beta_2}$ is the vector of coefficients of time varying explanatory variables and X_{it} is the vector of time varying explanatory variables, $\bar{X}_i$ is the time average of time varying explanatory variables and $\boldsymbol{\beta_3}$ is the vector of parameters for the time averaged variables, $\boldsymbol{\alpha}$ is the coefficient for smallholders livestock commercialization and is the measure of commercialization, $\boldsymbol{\gamma}$ is the coefficient for time dummies and $\mathbf{T_j}$ is the indicator of time dummies and is an error term.

This model has a couple of advantage compared to naïve OLS estimation strategy. First, it controls for unobserved heterogeneity by using the time average of explanatory variables as a proxy for individual unobserved specific effects on commercialization and household welfare. These variables are constant across time but vary across individuals and hence mimic the effects of time invariant unobserved heterogeneity. Second, the standard errors are corrected for serial correlation by using generalized least square estimation strategy

However, as can be seen from the above model, the commercialization index itself is endogenous since a set of covariates in the model and welfare indicator itself determine the level of commercialization. Therefore, to handle commercialization index problem above the empirical modelling procedure involves the estimation of the likelihood of commercializing by household using a probit model.

$$P\,(HCIvalue_{it} = 1/R_{it}) = \phi\,(Z_{it}\,\varphi_t) \quad (8)$$

Where Z_{it} contain all the covariates which affects commercialization but not household welfare. From the above equation inverse mill ratio were estimated and included in the CRE model above to estimate the impact of commercialization on household welfare so as control for endogeneity of livestock commercialization.

Random effect modeling is relevant in this study since the covariates of interest are time invariant and hence becomes impossible to estimate with strict fixed effect model, which eliminates them by demeaning the variables with the purpose of eliminating unobserved heterogeneity.

The variables included in Probit equation for inverse mills ratio predictions include cost variables particularly market access, access to extension services and average values of sold livestock which are thought to affect commercialization but not household welfare indicator directly.

In this way the potential endogeneity of commercialization and unobserved heterogeneity of are controlled for and hence panel model provides consistent estimates compared to naïve OLS estimation strategies.

3.3. Definition and measurement of key variables

In this section we articulate how we measure the commercialization indices as well as a measure for household welfare which are fundamental to the objectives of the study.

Household Livestock commercialization indices

The level of livestock smallholders' commercialization was analyzed by calculating different commercialization indices of livestock smallholders. Specifically, for this study indices on output side of commercialization (market participation) were calculated. For the case of livestock commercialization in output side, two kinds of indices were calculated. The indices are explained below and how are they calculated.

The market off take rate; The approach by Negassa and Jabbar (2008) in determining the market position of livestock smallholder was adopted in this study to calculate net or market off take rate because this rate is considered to reflect household market participation for economical purposes (Jaleta, M. *et al.*, 2009). Because livestock type cannot be aggregated into one index using this index, each type of livestock is considered separately and determinants of the factors crucial for decision and intensity of commercialization were analyzed. The mathematical specification of the net or market off take rate is:

$$\text{Market or net off take rate} = \frac{sales - Purchases}{average\ inventory\ of\ the\ period} * 100 \quad (9)$$

This index is considered as a more relevant measure of smallholders' livestock real side commercialization and measures at what rate a household changes stock of livestock for profit purposes in integrating into off take of livestock (Jaleta, M., 2009).

In this index, average inventory of the period is defined as the average of stock of livestock for a particular period of time, mathematically;

Average inventory (stock) = 0.5 (Opening stock + Ending stock) (Negassa & Jabbar, 2008). The opening stock in this study is used as the number of owned animals in the begging of the year (past 12 months) and closing stock is the number of animals owned during the survey.

This index may generate net sellers (positive ratio), net buyers (negative ratio) and passive market participants (zero ratio) (Negassa and Jabbar, 2008). As can be noted, for a commercializing household the index does not indicate whether a household is keeping livestock for profit purposes since it is in real terms of livestock and not value of livestock. A passive participant may be considered as non commercializer but in real sense he/she might be maintaining the stock but purchase less and sell high valued livestock after rearing for sometimes particularly for-profit making reasons. In this study, this index is short as HCIrl[3]

Monetary value household commercialization; In this study we adopt monetary value commercialization namely Household Commercialization Index (HCI[4]) developed by different authors in crop commercialization as proportion of value of sold output over the value of total production (Jaleta, M. et, 2009). In the context of livestock commercialization, it is proportion of the value of sales of livestock and livestock products to the total value of owned livestock. It is used to indicate the readiness of the livestock smallholders to turn owned livestock for profit purposes. A value of 100 imply total value of owned stock equals to total value of sales and negative value showing net purchasers of livestock for the given period.

This index is adopted in the process of livestock commercialization because sometimes the value of sales matters to the farmer than the amount of sales/ purchases because it indicates the earning from livestock commercialization and therefore, in aggregates wants to maximize the value of transactions or profit. It also enables us to group all types of livestock in one index in output side of the

market rather than separate types of livestock because sometimes in Tanzania livestock keepers alternate selling of livestock depending on market lines and seasons. Mathematically;

$$\text{HCI in output market} = \frac{\textit{total values of sales}}{\textit{total value of stock of livestock under market value}} \quad (10)$$

Total value of stock of livestock is calculated by multiplying average stock to average value of a live sale under the particular period. Average value of a live sale is calculated by taking total sales value of the period divide by total number of sales of the period which gives market value of a particular livestock type. Then to get total value of the average stock, the market value of a particular livestock type is multiplied by total average stock maintained over the period of a year. In here the index is abbreviated as HCIvalue[5]

Therefore, market off take rate and monetary value commercialization indices in output side were used to evaluate, to what extent Tanzanian livestock keepers have been commercializing (smallholders/pastoralists).

Household welfare

Household welfare frequently in the literature has been measured as household consumption expenditure though the computation may differ according to the methodology adopted (Hentschel and Lonjouw, 1999; Samuel and Sharp, 2008; Solomon *et al.*., 2011 cited in Diyana, T. 2014). In this study two indices of welfare were used;

Total monthly food and non-food consumption expenditure in Tanzania shilling (TSH) which are calculated as an aggregate monetary value of the reported household total consumption on food and non-food items (in the survey coded as one week and month recall) are used as the measure of household welfare. To assess the impact of commercialization on household welfare, we estimate the effect commercialization index on these variables. The two indices do not take into differing household consumption patterns based on either adult, old or child consumption scales. Instead household consumption in monetary terms is aggregated so that could reflect funding of welfare in general for a household.

The use of total consumption as an indicator of household welfare is observed in other studies(Baisa, 2009; Muricho, 2015; Tekalign, 2014). The aggregate expenditure is considered to be valid because, smallholders especially poor usually

incrementally add to their total welfare and thus time weight becomes irrelevant in indices. Also, the choice of both food and non-food expenditure allows us to assess the impact of commercialization on asset accumulation as well as on subsistence expenditure.

4. RESULTS

4.1. Data and Descriptive statistics

This study employs three waves (i.e. 2008/09, 2010/11 and 2012/13) of publicly available Tanzania National Panel Surveys (NPS) data sets collected and administered by the National Bureau of Statistics (NBS). The NBS (2013) National Panel Survey brief report provides a detailed discussion of the sampling framework and survey implementation for the data sets. The first wave of the data covers a total of 3, 265 households but due to a small attrition (4 per cent on average) and households splits, the sample increased to 3,924 in the second wave and to 5,010 in the third wave. This study focuses only on livestock community and a balanced panel surveys by considering only those households who were surveyed throughout the three rounds. As a result, the effective sample for our study dropped to 989 livestock keepers tracked over three waves making a total of 2967 observations used in this study. The NPS is representative at national level.

Table 2 presents descriptive statistics for key variables in our sample. On average 75.25 per cent of the sample were male headed households with an average age of 25.14 years. Across waves, the age of the livestock keepers do not seems to change but deviation is higher within the waves. For pooled data and in years separately, the descriptive results are presented in Table 2.

Considering education, only 21.24 per cent among livestock keepers at least attended lowest level of education with standard seven education dominating the sample with 20.16 per cent had completed standard seven while very few completed Tertiary education level (only 0.07 per cent) and none ended on advanced secondary education, which implies that most if not all advanced secondary levers proceed to higher levels of education or employment different from livestock keeping. Standard seven levers according to Tanzania's context do not necessarily mean satisfactory human capital development but presents substantial differences from non-schooled individuals. As expected, these variables do not fluctuate much across years partly because of short time period and constant norms and population demographic structure of developing countries which has the most in bottom level of education.

In general, 98.15 per cent of livestock keepers were located in rural areas, which statistically in Tanzania are concentrated by large percent of poor dwellers. Within the waves, the number livestock community in the last two years increased to over 99 per cent (2011 and 2012 surveys). This implies that rural Tanzania as compared to urban areas is continuously dominated by large number of livestock keepers.

Welfare indicators namely total consumption of food and non-food items over one month varies substantially over years especially for non-food consumption. On average, an individual spent over 5400Tsh per month on food items. On the other hand, non-food consumption averaged almost 4000Tsh per month with substantial deviation between the highest and lowest valued non-food consumers. The deviation indicates high inequality in resources distribution. Consumption among households however, have been on average rising over the surveyed years, indicating improvement on household welfare overtime. Nonetheless, the increase is not linear with lower consumption in the middle wave.

On average, livestock keepers borrowed Tsh 890,000 per year though with huge variability across the years. The same can be said on average value of livestock held by livestock keepers. This notable variability on capital assets among households expanding across years implies for notable inequalities in the livestock sub-sector similar to inequalities in overall Tanzania's population

On the side of marital status 34.55 and 15.29per cent were living under monogamous and polygamous marriage respectively and with small variation over the years. Likewise, household size averaged to over 9 members and was almost constant across the years. Commercialization indices both on monetary commercialization and real commercialization vary across years and across types of livestock. The commercialization indices are more discussed in the latter subsections.

The results show that majority of livestock keepers have no access to extension services with only 35 per cent reported to have access on the same. Most (99 per cent) of those with access are confined to services related to diseases management and only 33 per cent have access to livestock production related services. For market services, most seems to sell their livestock on village market (over 70 percent) and few across district or region. This pattern suggests that livestock trade is still underdeveloped with low competition in terms of prices outside the locality or with middle men domination on the lower level of the value-chain.

With the descriptive statistics above, it is worth examining the variables according to levels of commercialization[6] and as well in the context of panel data. This analysis

has significant importance given the variability of the data as shown above. First, it tells whether the variation is because of panel nature or between subjects. Secondly, it shows whether the variation is contributed by the levels of commercialization among households which pioneers the variables explaining differences in levels of commercialization. These descriptive statistics are presented in the Table 3 below for the key variables of interest.

Education and commercialization; the proportion of commercializers for all levels of education is higher than the proportion of non-commercializers. The proportion is 1.5per cent for commercializers and 0.9 per cent for non-commercializing group, commercializers (0.3 per cent) compared to non commercializers (0.03 per cent) and commercializers (36.6 percent) compared to non-commercializers (20.2 per cent) for ordinary, tertiary and primary levels of education respectively. This signifies the importance of education in commercialization though with nonlinear relationship. The descriptive statistics indicate that education plays a role in commercialization.

Gender and levels of commercialization; The percentage distribution of sex among levels of commercialization in the context of panel data structure shows that, the large percent of male are commercializers compared to their female counterpart. This may suggest that men are probably better than female when it comes to commercialization. Moreover, the within proportion variation of gender is smaller in the commercializers compared to non commercializers implying that commercializers do not tend to change in terms of gender and is for a specific group which has managed to cross the fixed decision of deciding to commercialize.

Commercialization is more associated with the usage of extension services. The descriptive statistics reveals that about 40 per cent of commercializers had some contact with extension services as compared to 35 per cent for the non-commercialization group. Market access do not seem to present substantial differences between commercializers and non-commercializers.

The household location for different levels of commercialization requires special attention. One of the reasons is that for developing countries like Tanzania, the difference between rural and urban dwellers is potentially re-emphasized because of differences in challenges and opportunities between these two communities. Descriptive statistics shows that 99 per cent of non-commercializers as opposed to 91 per cent of commercializers were in rural areas. This implies that high per cent of non-commercializers are in rural areas relative to per cent of commercializers. On this ground, the statistics shows 1 per cent of urban dwellers are non-

commercializers while 9 per cent are commercializers. This means that urban dwellers have clear advantages on access to information and market than rural dwellers even though they have comparative advantages on livestock commercialization due to public land and water bodies.

On the side of welfare, commercializers consume less than non-commercializers in both food and non-food items however the difference is higher on non-food items. This can be explained on the grounds that non-commercializers might not depend entirely on livestock and therefore their welfare depends much on other non-farm activities or mixed farming. It is important to note that deviation among non-commercializers is high in both welfare components which imply that commercialization reduces welfare differences among livestock keepers.

4.2. Extent of livestock commercialization

To what extent Tanzanians have been commercializing is another question of inquiry of this study. Both markets off take rate for different types of livestock and household livestock commercialization index in general were used to examine the extent of smallholders' livestock commercialization.

In general, descriptive statistics shows that, the level of commercialization among livestock smallholders is very low. On the side of value commercialization on average the level of commercialization is 21.6 per cent which is low compared to the average standard (50 per cent). For the market off take rate, the off takes of live animals for market is again very low which is not exceeding 3.2 per cent per livestock keeper which is again low and indicates that efforts are still needed to make this sector commercialized. These results support finding from other African nations which indicates that livestock commercial off take rate is very low(Berhanu Gebremedhin *et al.*., 2015; Covarrubias *et al.*., 2012; Negassa & Jabbar, 2008). More importantly, commercialization both in market off take rate and monetary value commercialization do not vary across waves which implies that people do not yet change to more commercialized livestock keeping.

In general, extent of commercialization varies across gender by monetary commercialization and livestock types. For the pooled sample, except for pig and chicken, male seems to be better commercializers with higher commercialization index on average than female counterpart. For the waves, females are better commercializers than males in the last two waves but with small dominance but not constant across livestock types. However, in general the rate or extent of commercialization is very small across gender groups.

Considering level of education, the extent of commercialization is heterogeneous across levels of education. Tertiary education has higher average commercialization index for value commercialization but do not appear for specific types of livestock. For other levels of education there is no clear pattern with commercialization but for the level of commercialization increases with the level of education.

4.3. Determinants of livestock commercialization

The study is meant to analyze the significant factors contributing to differing levels of commercialization among households as well as decision to become a potential commercializer. Specifically, the role of education (human capital development) and gender (inequality in commercialization between genders) were key objective of the study. However, age (accumulated human life experience) and household location (urban versus rural opportunities differential) have been given a special attention as well.

Determinants of commercialization in this study are analyzed using monetary value commercialization. The estimation strategy proposed in this study was the CRE random effects double hurdle model to capture the signs (direction) as well as magnitudes of the estimated parameters of the key household level determinants of livestock commercialization. The determinants of participation decision and intensity of participation in livestock market were estimated as two delinked decision using CRE probit and Tobit models, respectively. The reason for using this approach follows the reasoning of Maddala (2001, 336) as cited in Hino, A. (2010) that in the case, censored zero observations naturally arise because of negativity and non-observability of the data then Tobit censored dependent variable regression model is more appropriate than a two tie model (DH) (Hino, 2010).

Naturally, commercialization indices can take a value of positive, negative, zero as well non-observed in the survey. The study thus estimated the Tobit model as intensity of commercialization model instead of being conditional only on positive values. In addition to that, to link two commercialization decisions that is intensity decision being conditional on participation decision, a pooled data double hurdle model is estimated. Likewise, robust check is done by estimating the models with bootstrapped standard errors in case heteroscedasticity and/or serial correlation is present in the data. Both results are presented and discussed.

All estimation strategies undertaken are based on truncation of the survey data, which tend to produce bias results for the normal linear panel model. The choice of using random effects estimation strategy allows for the estimation of the coefficients

of the dummy variables as well as control for endogeneity due to an unobservable (Woldeyohanes *et al*.., 2015; Wooldridge, 2013). We estimate all three models so as to have more insight on livestock commercialization processes as a two-stage process but with robust estimates.

4.4. Robustness Checks

The econometric results reveal that there is a small difference on both signs and significance of the estimated coefficients in Pooled data double hurdle equation and Tobit model with bootstrapped and normal standard errors which suggests presence of serial correlation and heteroscedasticity as suggested by the diagnostic test which adversely affect DH model although there is consistency in most of the coefficients. In that case the coefficients with bootstrapped standard errors are superior (Wooldridge, 2013). There is no difference in probit equation for both with and without bootstrapped standard error and thus normal coefficients are considered superior.

Likewise, CRE probit model produces most significant coefficients compared to the Pooled double hurdle model in a hurdle equation which suggest the same problem of serial correlation of the standard errors. However, the models are not directly comparable because of a couple of reasons. Although the models use the same estimation strategy, CRE probit and tobit model are two separate equations in which there is no conditional dependence between the two while in Pooled data double hurdle model, above equation (intensity) is conditional on hurdle being passed.

Although Pooled double hurdle model may not have econometrically good (robust) results because of serially correlated standard errors, in this case it provides a better insight that commercialization is a two-way decision processes and the decisions are not taken simultaneously. Determinants of these processes differ and one variable (force) may influence them differently although they may be linked in some way (Woldeyohanes *et al*.., 2015).

Interpretation of the key variables of interest

Although models with latent variable representation of the actual variables there is no direct magnitude interpretation of the coefficients, the direction of the effect of regressors on latent variable is the same as that on actual variable (Hino, 2010; Verbeek, 2004; Woldeyohanes *et al*.., 2015). Therefore, for magnitude interpretation, average marginal (partial) effects were estimated and interpreted in the last part of this subsection.

Education shows the effects of human capital investment on the decision and level of livestock commercialization which as well theoretically is expected to have positive effect. Surprisingly, only primary and ordinary level of education is found to have significant effect on intensity of commercialization and yet negative effect. When standard errors are bootstrapped, only primary level of education is found significant (negative), and all other levels of education are found to be no different from non-schooled households both in participation and intensity of livestock commercialization. This means individuals with education commercialize less compared to non-schooled counterparts. The reason for these results is that schooled households may have other livelihood means other than livestock and hence do not depend on livestock for subsistence and welfare improvement. These results are contrary to what Muricho (2015) has observed in crop commercialization in which education of the household head had significant and positive effect on both intensity and decision to commercialize (Muricho, 2015) in which he related the effect of education to commercialization as increases both access to information and better skills (Mottaleb *et al*.., (2015), Gebremedhin and Jaleta (2010) as cited in Muricho (2015)).

Gender of the head of the household is also a key variable of interest in this study aiming at explaining whether there is gender difference in commercialization. Gender brings differences in decision making and inequality in many spheres of life like resources access particularly in developing nations. In this study, gender of the livestock keeper is found to significantly affect the decision to commercialize and not intensity to commercialize where men decide to commercialize worse than female. However, conditional on participation decision, male commercialize better than female. When decisions are taken as separate, males and female do not differ in commercialization. These results suggest that women are likely to cross the hurdle of deciding to penetrate on marketing blocks, not better on intensity of commercialization. Women tend to have fewer resources and thus their level of commercialization is limited to what they have. In livestock communities male control livestock except for few livestock products such as animal skin and milk. The results are contrary to what Muricho (2015) and (Baisa, 2009) observed on the side of crop commercialization whereby no significant effect of gender differential on crop commercialization particularly decision to participate in crop market is found.

Other variables considered include age of the household and household location whether urban or rural. The results show that age of the household positively influence extent of livestock commercialization in monetary value commercialization

but not participation decision. In the pooled data double hurdle model, age of household head is significant in influencing both intensity equation and participation decision but the effect is negative on the later (1 per cent level of significance). The results imply that life experience significantly affect the level of commercialization. These results are consistent with results found by Muricho, G. (2015) in crop production who concluded that within-household age variation have effect on intensity to commercialize but not binary decision ((Muricho, 2015). Baisa(2009) also found that age has no effect on household crops market participation(Baisa, 2009).

Household location in this study was whether a household dwells in urban or rural counterparts. The interest in the study is to see whether urban dwellers tend to commercialize better than rural dwellers because of favorable urban environments than rural environments such as better infrastructure, access to market and market information and higher demand of animal product compared to rural areas. The results show that urban dwellers commercialize better than rural dwellers. This means that although rural households have a higher comparative advantage in animal keeping than urban counterparts because of large public grazing land, public water bodies (URT,2015) and higher specialization which gives them the better call in this subsector, smooth market information and infrastructure accompanied by high demand of animal products in urban areas are supportive in urban livestock commercialization. Our results suggest that because rural dwellers have better comparative advantage promoting this sector particularly in rural areas is likely to pull out majority from the trapped corner solution of welfare maximization and achieve Global goals of ending hunger by 2030.

Other controls in this study were household access to credit, household size, occupation of the household head and year's dummies as well as average of time varying explanatory variables mainly for identification purposes and control of unobserved heterogeneity between households[7].

Average marginal effects

To facilitate the interpretation on the effects of key variables on household commercialization, average marginal (partial) effects were computed for both CRE Tobit and Probit model but with no bootstrapped standard errors to avoid unnecessarily larger standard errors. Marginal effect shows the effects of a unit change of explanatory on dependent variable, in this case the effect on household commercialization (Verbeek, 2004; Wooldridge, 2013). Therefore, to say about the magnitude of effect of explanatory variable on decision and intensity of

commercialization, average marginal effects theoretically perform this particular task. For CRE Tobit model both conditional on being uncensored and unconditional average/marginal effects were calculated while for the probit model the marginal effect of explanatory variable on a household moving from non-commercializing to a commercializing household were estimated.

Unconditional marginal effect shows the instantaneous change of dependent variable as a result of a unit change in explanatory variable regardless of censoring of the variable that is dependent variable taking its actual or observed value ((Wooldridge, 2013).

The conditional marginal effect that is conditional on being uncensored shows the same results as unconditional marginal effect for the same set of explanatory variables in significant but slightly differences in magnitude.

The marginal effects are discussed only for significant variables. Education is found to have negative effect on intensity of commercialization where livestock keepers who complete primary and ordinary level of education reduces the selling of animals by 8 and 12 units respectively. This further suggest subsistence animal keeping where schooled household have other means of feeding a household other than selling animals.Gender only affects participation whereby, the sudden change from female to male reduces the probability of being a potential commercializer by more than 11 per cent. Animal loss due to diseases, one additional loss of livestock reduces the intensity of commercialization by more than one unit while Livestock loss due to theft and diseases reduces the probability of becoming a potential market participant by more than 44 and 16 per cent respectively. Selling to a near town market increases the number of animals sold by more than three units which suggest that near town market is easier to access (low transaction cost) and with improved prices due to high animal products demand.

One additional unit of visit time by extension officer, reduces the commercialization of livestock by 0.31 units. The reason is that, livestock keepers who had contact to extension officers, 99 per cent are about livestock diseases which ultimately increases their chance of controlling for diseases and hence no more sells.

In terms of household location, when a household shift from rural to urban areas the rate of selling livestock improves by more than 20 units on intensity livestock sell (as value terms) conditional on being censored (positive sales) while over 25 units for unconditional commercialization (uncensored). On other hands, an increase in on year of the age of the household head increases the chances of a household to sell animals by 51.67 per cent but insignificant for high levels of age.

In case of household size, an increase in one member in the household reduce animal sold by a household by more than 1 unit. The effect is the same for unconditional market intensity. For market participation decision, the chances of a household becoming a potential commercializer fall by 0.08 percent. This implies that, increase in members of the household cause the family or livestock keepers to be more protective for consumption smoothing.

In general, conditional on being uncensored, the marginal effects on commercialization of all key variables increases. This implies that given that a household has moved out of a corner solution (zero commercialization) the effects of additional unit or change of explanatory variable on commercialization level increases. Therefore, eliminating a constraint on deciding to commercialization improves the effect of policy or exogenous variables on household commercialization.

4.5. Commercialization and household welfare

Total monetary value of food and non-food items consumed by a household past one month in this study are used as measure household welfare. These are considered as short-term nutritional and assets accumulation effects of household livestock commercialization. The results for a two stage CRE model on welfare analysis are presented on table 8.

The results show commercialization mills ratio which is used to control for endogeneity of the household commercialization affects positively only total one-month non-food expenditure. The effect on food expenditure although negative is not statistically significant up to 10 per cent level. The results imply that higher commercialization significantly improves total non-food expenditure but not food items.

The possible explanation of this is that livestock keepers tend to have a pre-determined level of food consumption like two meals per day (for adults), one in the morning and hence grazing follows and later in the evening. For children, there is always reserve food for the rest of the day. This means that animals are sold only to achieve the predetermined level of food expenditure and no more. Extra sells of animals are for non-food items including household assets accumulation. These results are similar to many findings found in crop commercialization literature, where major conclusion is that welfare among smallholders increases with the level of commercialization (Baisa, 2009; Jaleta *et al*.., 2009a; Kamaghe *et al*.., 2014a; Tekalign, 2014; Kamaghe, Mlozi, Mejer, & Johansen, 2014b).

5. CONCLUSION AND POLICY IMPLICATION

Livestock commercialization in recent policy initiatives in Tanzania has been observed as the means to move out of poverty trap especially through creating employment and income. However, the sector seems to be not moving particularly to the desired direction and livestock keepers still live in extreme poverty compared to other societal groups. The likely hinders of the development of this sector looks not yet clear however norms and cultural practices are observed to play great part associated with inequality between genders. An understanding of the factors hindering the development of the sector then becomes a question of inquiry to policy makers, practitioners and academicians. Empirical works have noticed impacts of several factors on livestock commercialization in the world but limited locally and most not country representative which has motivated the undertaking of this study.

Therefore, this study was initiated with the objectives of using empirically strong methods and national representative data to examine the role of gender and education status of the livestock keeper on livestock commercialization for decision to and intensity of commercialization and effects of commercialization on household welfare. CRE probit and Tobit models were used to analyze determinants of commercialization while two stage CRE model was used to link commercialization and household welfare.

The results reveal that the decision and intensity of commercialization are too separate processes with different forces.

On summary, the determinants of household commercialization differ between whether a household commercialize or not and by how much a household commercialize although these two decisions in this study are not taken as conditional on one another instead each decision is modeled separately. On the side of by how much a household commercialize household size, age, education level particular standard seven and ordinary level of education, visit times by extension officer, value of live sales, near town market, location (rural) and livestock loss due to diseases are found be significant. On the other hand, the value of live sold animals, natural log of credit access, school attendance by a livestock keeper, gander, livestock loss due to diseases and theft are found to be significantly affect market participation decision however with different signs and level of significance. These results show that these commercialization decisions are different processes with different forces. The phenomenon is observed by other researchers (Baisa, 2009; Jaleta *et al.*., 2009a; Negassa & Jabbar, 2008; Tekalign, 2014; Woldeyohanes *et al.*., 2015).

Gender and education as key variable in this study were given special attention. Gender is found to significantly affect the participation equation in favor of female but on intensity of commercialization both genders are found to be equal while education is found to play little role in commercialization. Levels of education are not found to significant in affecting both participation and intensity of commercialization.

On the other hand, commercialization was only found to have impacts on non-food welfare component but not food welfare component and seems to depend heavily on the other attributes of the household.

Lastly, the extent of commercialization is found to be very small across livestock type, gender and levels of education and even below average level of commercialization. This suggests that Tanzanian livestock keeper's still keeps and off take livestock according to subsistence needs and not income generating activity.

To conclude gender is found to have impact on household livestock commercialization but only on crossing the first hurdle of commercialization in which females are observed to be better in that. Education is found to affect negatively intensity of commercialization which suggest education as a substitute of livestock commercialization since schooled households head are likely to feed the household through other means of income generation.

In Tanzania, livestock keeping seems to be for subsistence purposes with extreme low level of commercialization. However, for commercializing household, commercialization tends to improve household welfare especially non-food consumption which can be referred as asset accumulation.

Policy Implication

The result from this study has several implications. First, livestock commercialization is still lower among livestock keepers which imply they still keep livestock for subsistence purpose. Therefore, to pull livestock keepers out of trapped viscous circle of poverty efforts are still needed to educate them on better resource use for welfare improvement rather than keeping livestock for norms and culture only. Moreover, although institutional factors like markets and marketing were not found to be significant in this study the role of government on establishment of markets and slaughtering factories across the country is required to attract livestock keeping for business.

Second, females are found to be better on commercialization participation decision but not on intensity of commercialization which means breakthrough costs on how much to sell is excluding them from selling much. Also, females are likely to own less and hence do not have much to sell. Therefore, these results imply that given assets ownership both males and female are likely to commercialize equally.

Education is found to be less important on livestock commercialization because it acts as substitute to livestock sells. Probably, the kind of education received particularly primary and ordinary level of education do not build self-reliance behavior or business mind set which is likely to turn subsistence keeping into business oriented.

Livestock commercialization is found to improve household non-food expenditure like assets accumulation. Therefore, political and civic education effort is important in these communities to use assets they have for their life time improvement.

Notes

1. Model specification includes the explicitly specifying the independent variables to be included in the regression equations, particularly in both hurdles under this study.
2. See Wooldridge (2013) for CRE non-linear models as a way to control endogeneity.
3. HCIrl is Household Commercialization Index real side
4. HCI index is mainly in previous studies employed in crop commercialization, see Jaleta, M. *et al.* (2009)
5. HCIvalue is Household commercialization index in monetary value
6. The groups of commercialization herein are formed according to monetary value commercialization index. Market off take rates therefore may fall in different categories of commercialization even though the particular index do not seems to reflect a particular category.
7. Occupation of the household head and credit access were found to have no effect on commercialization while household size have negative effect. Animal loss due to diseases and value of livestock sold had negative and positive effect to commercialization respectively.
8. For all econometrics results, we also controlled for livestock loss (theft and diseases), year dummies, occupation of the household head, household location and market access (categoriezed as village, district, regional and international market)

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Table 2: Descriptive Statistics of the Key Model Variables

Variable and Type	*Pooled data*		*Year 2010*		*Year 2011*		*Year 2012*	
	Mean	*Standard Dev.*	*Mean*	*Standard Dev.*	*Mean*	*Standard Dev.*	*Mean*	*Standard Dev.*
Commercialization Indices								
Monetary Index								
HCI value	21.6107	34.0342	20.9242	33.3755	22.5379	33.4534	21.3700	35.2546
Market off take rate								
Bull HCIrl	0.0317	0.1977	0.0260	0.2077	0.0270	0.1456	0.0420	0.2299
Cow HCIrl	0.0185	0.1266	0.0043	0.0415	0.0289	0.1782	0.0223	0.1197
Goat HCIrl	0.0159	0.1112	0.0080	0.0830	0.0227	0.1420	0.0171	0.1000
Sheep HCIrl	0.0043	0.0493	0.0024	0.0326	0.0051	0.0530	0.0055	0.0584
Pig HCIrl	0.0045	0.0798	0.0016	0.0344	0.0059	0.1137	0.0060	0.0708
Chicken HCIrl	0.0188	0.1599	0.0358	0.1779	0.0146	0.2060	0.0060	0.0466
Welfare Measures								
Total Food expenditure (one-month recall)								
Food items expenditure (Tsh)	5451.1830	2500.0130	3841.1020	1808.0880	4983.9690	1574.2560	7528.4770	2425.3610
Total non-food expenditure (one-month recall)								
Non-food items expenditure (Tsh)	3598.6400	6407.8580	1950.9840	2334.1940	3634.1780	5573.9820	5210.7570	9023.6890
Other Social Economic Characteristics								
Age of household head	25.1445	18.5804	26.3950	16.1245	23.7139	19.7584	25.3246	19.5537
Years of schooling	13.9151	3.5671	14.5178	3.1733	13.8166	3.6116	13.4109	3.8022
Sex (1=Male)	0.7524	0.4316	0.7545	0.4305	0.7518	0.4321	0.7510	0.4325
Household location(1=rural)	0.9815	0.1349	0.9555	0.2063	0.9939	0.0777	0.9949	0.0710
Household amount of credit	890514.8000	372983.4000	589909.1000	117879.0000	994400.0000	155129.8000	1087235.0000	489565.5000

Household size	9.8798	5.0517	8.9762	1.8427	10.3185	6.0856	10.3448	5.9121
Monogamous marriage	0.3455	0.4757	0.4254	0.4950	0.2808	0.4497	0.3554	0.4790
Polygamous marriage	0.1529	0.3600	0.1798	0.3845	0.1486	0.3559	0.1396	0.3469
Household average value of livestock	1204292	9385680	1078244	15400000	888626	2209185	1646007	4825690
Education levels								
Form Four (1=completed FF)	0.0101	0.1001	0.0040	0.0635	0.0091	0.0950	0.0172	0.1300
Form Six (1=completed FS)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tertiary education (1=Completed TE)	0.0007	0.0260	0.0000	0.0000	0.0000	0.0000	0.0020	0.0449
Primary School (1=Completed PS)	0.2016	0.4012	0.1476	0.3549	0.2103	0.4077	0.2467	0.4313
Number of Observations	2967		989		989		989	
HCI value=Household value commercialization Index								
HCIrl=Household real commercialization Index								

Source: Authors' computations from NPS Panel data wave 1, 2 and 3:

Table 3: Descriptive statistics according to levels of commercialization (between and within Variation)

Variable and Type		*Pooled Sample*		*Non commercializing group(index<=50)*		*Commercializing group (Index>50)*	
		Mean	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*
Commercialization Indices							
Monetary Index							
HCI value	overall	21.6107	34.03421	11.17338	15.54283	101.4577	31.02871
	between		22.51943		11.2356		28.41676
	within		25.52538		11.38524		14.45718
Market off take rate							
Bull HCIrl	overall	0.0316636	0.197729	0.0148422	0.0925535	0.1603499	0.5045687
	between		0.111734		0.054311		0.4826025
	within		0.163159		0.074444		0.2162952
Cow HCIrl	overall	0.0184601	0.126611	0.012616	0.0765286	0.0631681	0.3030505
	between		0.073197		0.0572961		0.2852712
	within		0.103326		0.0576419		0.1338764
Goat HCIrl	overall	0.0159404	0.111237	0.0161186	0.1065387	0.0145773	0.1423191
	between		0.063709		0.06661		0.1072004
			0.0912		0.0852665		0.0854982
Sheep HCIrl	overall	0.0043375	0.049256	0.0049045	0.0523506	0	0
	between		0.028226		0.0309779		0
	within		0.040373		0.0420925		0
Pig HCIrl	overall	0.0045091	0.079833	0.0037012	0.0716964	0.01069	0.1257172
	between		0.046366		0.0400662		0.1292192
	within		0.065		0.058293		0.038236
Chicken HCIrl	overall	0.0187935	0.159851	0.0212501	0.1698277	0	0
	between		0.094356		0.1030669		0
	within		0.129056		0.1347045		0

Welfare Measures							
Food expenditure (one-month recall)							
Food items expenditure (Tsh)	overall	5451.183	2500.013	5457.677	2513.918	5401.503	2393.92
	between		1183.832		1402.567		2385.418
	within		2202.17		2137.691		904.2931
Total non-food expenditure (one-month recall)							
Non-food items expenditure (Tsh)	overall	3598.64	6407.858	3751.11	6644.265	2432.219	3996.547
	between		4084.492		4095.833		4259.734
	within		4938.503		5127.69		888.3576
Other social economic characteristics							
Age of household head	overall	25.14447	18.58035	22.962	17.53651	41.84066	17.86785
	between		12.15398		12.07076		17.85388
	within		14.05737		13.06561		5.402831
Years of schooling	overall	13.9151	3.567086	14.13591	3.444871	12.22587	4.012228
	between		2.284437		2.317182		3.899014
	within		2.74025		2.592748		1.24034
Sex (1=Male)	overall	0.4395012	0.49641	0.4344512	0.4957792	0.4781341	0.5002514
	between		0.301941		0.3278252		0.4756382
	within		0.394101		0.3805374		0.209427
Household location(1=rural)	overall	0.9814628	0.134906	0.9900915	0.0990661	0.9154519	0.2786145
	between		0.076429		0.0657096		0.272831
	within		0.111186		0.0781018		0.1081476
Household amount of credit	overall	890514.8	372983.4	885435.9	250433.7	929369.3	850743.6
	between		176002.7		103973.1		931307.8
	within		328877.7		231932.6		110850.3
Household size	overall	9.879829	5.05168	10.15269	5.185685	7.792378	3.182929
	between		4.073395		4.063125		3.270609
	within		2.989667		3.077332		0.6613501
Monogamous marriage	overall	0.3454842	0.475655	0.2993464	0.4581215	0.5746753	0.4951967

	between		0.388987		0.3851289		0.4816152
	within		0.300305		0.2815061		0.158028
Polygamous marriage	overall	0.1528836	0.359973	0.1418301	0.3489898	0.2077922	0.4063875
	between		0.297028		0.2879063		0.4000064
	within		0.214474		0.2095913		0.1067738
Household average value of livestock	overall	1204292	9385680	1337036	9972801	188781.2	91215.64
	between		5524821		8029747		84332.38
	within		7588671		7061903		45476.41
Education levels							
Form Four (1=completed FF)	overall	0.0101112	0.100062	0.0095274	0.097161	0.0145773	0.1200282
	between		0.066303		0.0694835		0.1072004
	within		0.074962		0.0704		0.038236
Form Six (1=completed FS)	overall	0	0	0	0	0	0
	between		0		0		0
	Within		0		0		0
Tertiary education (1=Completed TE)	Overall	0.0006741	0.025959	0.0003811	0.0195217	0.0029155	0.0539949
	between		0.014982		0.0159638		0.0298807
	Within		0.021202		0.0138066		0.038236
Primary School (1=Completed PS)	Overall	0.2015504	0.401226	0.1814024	0.3854247	0.3556851	0.4794198
	between		0.258986		0.2601434		0.4643362
	Within		0.306519		0.2890601		0.1513423
Number of Observations		2967		2624		343	
HCI value=Household value commercialization Index							
HCIrl=Household real commercialization Index							

Source: Authors Computation from NPS Panel data wave 1, 2 and 3.

Table 4: Extent of Livestock Commercialization by Gender

Variable	*Pooled sample*				*Year 2010*				*Year 2011*				*Year 2012*			
	Male		*Female*		*Male*		*Female*		*Male*		*Female*		*Male*		*Female*	
	Mean	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*
HCI value	22.0673	34.64817	21.25267	33.55105	27.64721	37.72757	17.66371	30.54767	21.44295	32.5091	23.54567	34.30022	19.09615	34.18497	23.76171	36.22729
Bull HCIrl	0.0584865	0.2650505	0.010631	0.1169955	0.0612578	0.320296	0.008827	0.1163498	0.046384	0.1937574	0.009214	0.074362	0.068036	0.283362	0.014638	0.150494
Cow HCIrl	0.0051099	0.0512927	0.028928	0.1621596	0.0017544	0.0240847	0.0054638	0.0476501	0.008157	0.0667829	0.0479266	0.236982	0.004399	0.04712	0.041051	0.162516
Goat HCIrl	0.016644	0.1179476	0.015389	0.1057099	0.0081994	0.0724391	0.007953	0.0876817	0.02112	0.1521722	0.0241465	0.132012	0.017839	0.103792	0.016306	0.095917
Sheep HCIrl	0.0053191	0.058109	0.003568	0.0410001	0.0031576	0.0395499	0.0019853	0.0286447	0.006908	0.0681609	0.0034404	0.033338	0.005211	0.057893	0.005891	0.058969
Pig HCIrl	0.0042029	0.0872695	0.004749	0.0735037	0	0	0.0023774	0.0419424	0.005626	0.1224841	0.0061489	0.105075	0.00555	0.074652	0.006531	0.066519
Chicken HCIrl	0.0099275	0.0833019	0.025746	0.2001255	0.0179358	0.1409407	0.04445	0.1927865	0.006276	0.0472035	0.0222905	0.281723	0.00824	0.05558	0.003592	0.034627
Observations	1304		1663		323		666		474		515		507		482	

Source: Authors Computation from NPS Panel data wave 1, 2 and 3:

Table 5: Extent of Commercialization by Levels of Education

Variable	*Non-schooled*		*Completed Primary education*		*Completed Secondary Education*		*Completed Tertiary education*	
	Mean	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*
HCI value	18.71642	31.93971	32.40628	39.25639	29.99074	34.50946	50	70.71068
Bull HCIrl	0.0234244	0.1774787	0.058311	0.2239	0.1444444	0.6293178	0	0
Cow HCIrl	0.0119473	0.100701	0.040998	0.1886752	0.0777778	0.2688607	0	0
Goat HCIrl	0.0191871	0.1233445	0.004106	0.0418195	0	0	0	0
Sheep HCIrl	0.0049041	0.0526967	0.001352	0.0241247	0.02	0.1095445	0	0
Pig HCIrl	0.0045123	0.071004	0.000279	0.0068155	0.0888889	0.4868645	0	0
Chicken HCIrl	0.0236521	0.1796655	0.000811	0.014349	0	0	0	0
observations	2337		598		30		2	

Source: Authors Computation from NPS Panel data wave 1, 2 and 3:

Table 6: Econometric estimation results, pooled data double hurdle, CRE Tobit and Probit models[8]

Independent Variables	*Dependent variable: HCI value: CRE Tobit*		*Dependent Variable: dummy HCI value: CRE Probit*	
	Coefficient with Normal standard errors	*Coefficient with Bootstrapped standard errors*	*Coefficient with Normal standard errors*	*Coefficient with bootstrapped standard errors*
Above equation (Intensity equation)				
Household size	-1.7315***	-1.7315***	-0.0027	0.0052
Household size squared	0.0320***	0.0320***	0	-0.0001
Live sales value	-0.0000**	-0.0000***	-0.0000**	-0.0000*
Visit times by Extension officer	-0.4944*	-0.4944	0.0036	0.0013
Natural log of household credit access amount	-0.7867	-0.7867	-0.2975*	-0.2988
Whether Ever attended school(1=Yes)	-1.1374	-1.1374	0.2183*	
Years of schooling	-2.4804*	-2.4804**	0.0196	0.0115
Age of the respondent	0.9187***	0.9187***	0.007	0.0118
Age squared	-0.0036*	-0.0036*	0.0004***	0.0003
Gender(1=Male)	-1.3249	-1.3249	-0.3539***	-0.2775***
Completed Ordinary education (1=Yes, 0 otherwise)	-13.8156*	-13.8156	0.1191	0.0265
Completed Tertiary education (1=Yes, 0 otherwise)	16.2546	16.2546	-0.5163	-0.7339
Completed Primary education (1=Yes, 0 otherwise)	-19.2262*	-19.2262*	0.3262	0.3138
whether accessed extension service (1=Yes, 0 otherwise)	2.7151	2.7151	0.1257	0.2416
_cons	105.2665***	105.2665***	9.2923	9.1973*
sigma/sigma_u/lnsig2u				
Constant	10.5442***	10.5442***	-1.4177***	-1.6051***
sigma_e				
Constant	23.7678***	23.7678***		
N	2572	2572	2572	2943
chi2	1165.533	3063.1918	352.324	960.5235
Rho	0.1644	0.1644	0.195	0.1673

Legends: * p<.05; ** p<.01; *** p<.001

Source: Authors Computation from NPS Panel data wave 1, 2 and 3:

Table 7: Average Marginal effects for Tobit and Probit Models

Variable	*Tobit Average Marginal effects*							*Probit Average Marginal effects*	
	Conditional on uncensored			*Unconditional on being uncensored*				*Delta-method*	
	dy/dx	*Z*	*P>z*	*dy/dx*	*Z*	*P>z*	*X*	*dy/dx*	*P>z*
Household size	-1.0286	-5.8400	0.0000	-1.4245	-5.8500	0.0000	10.0385	-0.0008	0.8690
Household size squared	0.0196	6.0300	0.0000	0.0271	6.0400	0.0000	135.0460	0.0000	0.9170
Live sales value	0.0000	-2.6800	0.0070	0.0000	-2.6800	0.0070	355465	0.0000	0.0010
Visit times by Extension officer	-0.3083	-2.0500	0.0400	-0.4270	-2.0500	0.0400	2.2423	0.0011	0.8960
Natural log of household credit access amount	-0.7591	-0.7900	0.4300	-1.0513	-0.7900	0.4300	13.6886	-0.0933	0.0450
Whether ever attended school (1=Yes, 0 otherwise)	-0.7563	-0.7300	0.4670	-1.0474	-0.7300	0.4670	1.2527	0.0685	0.0180
Years of schooling	-1.7323	-2.7900	0.0050	-2.3991	-2.7900	0.0050	13.6144	0.0061	0.7380
Age of the respondent	0.5167	6.6200	0.0000	0.7156	6.6300	0.0000	24.7201	0.0022	0.3500
Gender(1=Male)	-1.0704	-1.6200	0.1050	-1.4824	-1.6200	0.1050	0.4988	-0.1110	0.0000
Completed Ordinary education (1=Yes, 0 otherwise)	-8.6839	-3.0400	0.0020	-12.2789	-3.0500	0.0020	0.0117	0.0373	0.7510
Completed Tertiary education (1=Yes, 0 otherwise)	4.8212	0.3700	0.7140	6.5325	0.3800	0.7070	0.0008	-0.1619	0.6690
Completed Primary education (1=Yes, 0 otherwise)	-12.2790	-3.0800	0.0020	-17.1969	-3.1200	0.0020	0.2325	0.1023	0.4950
whether accessed extension service e(1=Yes, 0 otherwise)	-0.2327	-0.1100	0.9130	-0.3224	-0.1100	0.9130	0.4040	0.0394	0.6310

Source: Authors Computation from NPS Panel data wave 1, 2 and 3:

Table 8: Impact of commercialization on household welfare, two stage CRE model

	Dependent Variable	
	Total non-food monthly Expenditure in Tsh	*Total food monthly Expenditure in Tsh*
Independent Variable		
HCI value Inverse Mills Ratio	1.21e+04**	-919.453200
Household size	443.3141***	74.3413*
Household size squared	-51.9939**	1.475200
Live sales value	-0.000400	0.0005***
Visit times by Extension officer	-808.1599**	58.740300
Natural log of household credit access amount	-8.900300	26.200600
Whether ever attended school (1=Yes, 0 otherwise)	-2.73e+03***	83.686600
Years of schooling	261.077200	-78.259800
Age of the respondent	44.111100	18.004200
Gender(1=Male)	658.7178*	-91.754500
Completed Ordinary education (1=Yes, 0 otherwise)	4002.7985*	641.960600
Completed Tertiary education (1=Yes, 0 otherwise)	-783.232400	-308.527300
Completed Primary education (1=Yes, 0 otherwise)	1412.859900	-789.017400
_cons	-10400.000000	4027.498900
N	2555.000000	2555.000000
chi2	227.729600	1389.503600
sigma_u	3059.413500	0.000000
Rho	0.213000	0.000000

Legends: *p<.05; **p<.01; ***p<.001

Source: Authors Computation from NPS Panel data wave 1, 2 and 3: