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# Determinants of Commercialization of Smallholder Wheat Farmers: Generalized Double Hurdle Approach

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***Abstract:*** *Wheat production and productivity in Ethiopia had grown recently but it cannot meet the growing domestic demand, as a result, government imports a large amount of wheat. With the data from 152 smallholder wheat farmers in Minjare Shenkora of Ethiopia, this study identified strategies to promote successful smallholder commercialization. Generalized double hurdle econometric model is used to analyze the data. Result of the study indicates that land size of wheat and mobile ownership have a direct relationship with decision to participate in the market but age and household size have an indirect relationship with decision to participate in the market. The results also show that the coefficients for household size and non-farm income have a direct relationship with level of commercialization, while number of oxen and distance from the farm to the market had an indirect relationship with level of commercialization. Commercialization can be promoted through improving ownership of assets such as land, oxen and increase access to market information.*

**Keywords**: Commercialization; Smallholder wheat farmer; Generalized double hurdle model; Minjare Shenkora; Ethiopia.

## 1. Introduction

Agriculture continues to be a strategic sector in the development of most low-income nations. It employs about 40% of the active labor force globally. In sub-Saharan Africa, Asia and the Pacific, the agriculture-dependent population is over 60%, while in Latin America and high income economies the proportions are estimated at 18% and 4%, respectively (World Bank, 2008) In Ethiopia, agriculture supports the livelihoods of about 80% of the rural population (FAO, 2016). Over 95 percent of the annual gross total agricultural output of the country is said to be generated from smallholder farmers with an average farm size ranging from 0.5 to 2 hectare (CSA, 2018).

Cereal is the single largest subsector of Ethiopia's agriculture. It dominates in terms of its share in rural employment, agricultural land use, and calorie intake, as well as its contribution to national income. The subsector accounts for roughly 60 percent of rural employment, about 73 percent of total cultivated land, more than 40 percent of a typical household's food expenditure, and more than 60 percent of total calorie intake. Cereal also contribute 30% of the country,s economy. (Rashid and Negass, 2013). and wheat is the fourth most widely grown cereal crop, after teff, maize, and sorghum (Minot et al., 2015)

Wheat production and productivity in Ethiopia had grown recently (CSA, 2018) but it cannot meet the growing domestic demand, as a result, the government imports a large amount of wheat. In 2018 alone, a record amount of 1.5 million metric tons of wheat that is more than three quarter of domestic production, was imported (USDA, 2019). This trend tends to continue in near future since population, urbanization, and change in preference and lifestyle grow (Mason et al., 2012; Minot et al., 2015).

Minjar Shenkora district is the largest wheat producer in Amhara regional state and the 11$^{th}$ largest in the country. The district and other tops 24 wheat-producing districts in the country contribute more than half (56%) of the total national wheat production (Minot et al., 2015). Though there are high production potential and spatial proximity to urban markets, there is poor vertical or horizontal linkage at the wheat value chain in the study area. This was primarily due to less commercialization of wheat grain producers.

Commercialization of smallholder agriculture – meaning a shift from subsistence to more market-oriented farming – leads to a gradual decline in real food prices (Jayne et al., 1995), reduces both income poverty and multidimensional poverty (Ogutu et al., 2019), has a positive association to household welfare (Muriithi and Matz, 2015) and improve nutritional status (von Braun, 1995).

While there is a relatively large body of existing literature on smallholder output market participation (D. A. . Alene et al., 2008; Barrett, 2008; Muricho et al., 2015; Omiti et al., 2009), our contribution focuses on commercialization. According to Pingali, (1997) and Moti et al. (2009), agricultural commercialization means more than the marketing of agricultural output. This study also used the generalized double hurdle model which assume independence and non-normality of the participation and level of participation errors

## 2. Materials and Methods

### *2.1. Study Area*

This study was carried out in the Minjar Shenkora district located in the central part of Ethiopia. The region is administratively divided into two urban and 27 rural Peasant Associations (PA) and has a total area of 229,463 hectares. According to the CSA (2017) report, the projected population of the district is estimated to a total population of 148,493.

### *2.2. Sampling and data collection*

The survey was undertaken through interview schedules by trained enumerators with randomly selected wheat smallholder farmers using pre-tested semi-structured questionnaires. The multi-stage sampling procedure was adapted to select smallholder farmers in Minjar Shenkor District. In the First stage, ten PA were selected from 27 total rural PA and this was due to only this peasant association's produce wheat. In the second stage, four PA were selected randomly from a shuffled pile of a wheat producer. In the third stage, 152 samples of household head were randomly selected from a total wheat producer in the district and the sample households were drawn randomly from each peasant association based on probability proportional to size sampling techniques suggested by Yamane (1967) formula

$$n = \frac{N}{1 + N(e^2)}$$

n = actual sample size;
N = total number of households in the four peasant associations;
e = margin of errors at 8% (the desired level of precision, e= 0.08).

**Table 1**
Sample size of wheat farmers

| Number | PA | Total number of wheat producer in each PA | Number of Sample household in each PA |
|---|---|---|---|
| *1* | *Cherecha* | *1413* | *41* |
| *2* | *Krstossemra* | *1298* | *38* |
| *3* | *Iran Buti* | *1456* | *42* |
| *4* | *Sama* | *1077* | *31* |
| *Total* | *4 PA* | *5244* | *152* |

### *2.3. Measuring agricultural commercialization*

In this paper, we use the Household Crop Commercialization Index (HCI), The same type of commercialization index was also used in previous studies (Abdullah et al., 2019; Carletto et al., 2017; Muriithi and Matz, 2015; Riwthong et al., 2017)which is defined as:

$$HCI = \frac{total\ wheat\ produced\ in\ kg}{total\ wheat\ sold\ in\ kg} * 100 \qquad (1)$$

### *2.4. Determinants of commercialization: Generalized double hurdle approach*

In this paper, a generalized double-hurdle model Cragg (1971) is used to analyses household commercialization of wheat. Various studies on smallholder market participation have mainly modelled output market decisions as a two-step decision process. This is based on the assumption that households make two separate decisions; one involves the decision to participate in the market or not and secondly the level of participation. These studies have used either the sample selection model of Heckman (1979) (Abdullah et al., 2019; Alene et al., 2008; Key et al., 2000; Mather et al., 2013) or the double hurdle model (Olwande et al., 2015; Omiti et al., 2009; Reyes et al., 2012; Woldeyohanes et al., 2017)

The double hurdle model define an initial discrete probability of participation model, conditional on participation, a second decision is made on the level of commercialization. Originally, such models were estimated using the Tobit model that accounts for

the clustering of zeros due to non-participation. However, a major limitation of the Tobit model is that it assumes that the same set of parameters and variables determine both the probability of market participation and the level of participation. A two-step model however relaxes these assumptions by allowing different mechanisms to determine the discrete probability of participation and the level of participation (Cragg, 1971).

$$y_{i1}^{*} = w_i'\alpha + v_i \qquad participation\ decision$$
$$y_{i2}^{*} = x_i'\beta + \mu_i \qquad Commercialization\ decision$$
$$y_{i2}^{*} = x_i'\beta + \mu_i, \quad if\ y_{i1}^{*} > 0\ and\ y_{i2}^{*} > 0$$
$$y_i = 0 \qquad otherwise \qquad (1)$$

Where $y_{i1}^{*}$ is a latent variable describing the household's decision to participate in the wheat output market, $y_{i2}^{*}$ is a latent variable describing level of commercialization, $y_i$ is the observed dependent variable degree of commercialization (HCI), $w_i'$ is a vector of variables explaining the participation decision, $x_i'$ is a vector of variables explaining the commercialization decision, $v_i$ and $\mu_i$ are the respective error terms assumed to be independent and distributed as $v_i \sim N(0,1)\ \ and\ \mu_i \sim N(0,\sigma^2)$

The double-hurdle model is built upon the normality assumption of the error terms the usual ML estimates which assume normality is inconsistent when the normality assumption is violated (Arabmazar and Schmidt, 1981). One way to accommodate non-normal error terms is by transforming the dependent and latent variables (Jones and Yen, 2000; Newman et al., 2003; Yen and Huang, 1996), in in which case the latent commercialization equation can be written as:

$$(T)y_{i2}^{*} = x_i'\beta + \mu_i \qquad (2)$$

where T(.) is some form of transformation.

Researchers across many disciplines transform dependent variable using the natural log or Box-Cox. This paper describes an alternative to the natural log and Box-Cox transformations commonly used in research. This alternative transformation—the inverse hyperbolic sine (IHS)—may be appropriate for application to commercialization because, in addition to dealing with skewness, it retains zero and negative values, allows researchers to explore sensitive changes in the distribution, and avoids stacking and dis-proportionate misrepresentation (Friedline et al., 2014). The IHS transformation of random variable $v$ is defined as (Jones and Yen, 2000) :

$$T(v) = log\left[\theta v + (\theta^2 + 1)^{\frac{1}{2}}\right]/\theta = sinh^{-1}(\theta v)/\theta \qquad (3)$$

The likelihood function of the IHS transformed double-hurdle model can be written as (Jones and Yen, 2000; Yen and Huang, 1996)

$$L = \prod_{y_i=0}[1 - \Phi(w_i'\alpha]\prod_{y_i>0}\Phi(w_i'\alpha]\left[\Phi\left(\frac{\chi_i'\beta}{\sigma_i}\right)\right]^{-1}\frac{1}{\alpha_i}\phi\left[\frac{T(y_i-\chi_i'\beta}{\sigma_i}\right]\frac{1}{(1+\theta^2 y_i^2)^{\frac{1}{2}}} \qquad (4)$$

where $\phi$ (.) and $\Phi$ (.) are standard normal density and cumulative distribution functions, respectively.

## 3. Results and discussion

### *3.1. Descriptive information*

Fig one shows level of commercialization of sample households. More than quarter of wheat producer were subsistence and less than 25% of wheat producer sold halve of their produce. The average HCI is about 34%, indicate moderate commercialization

in the study area.

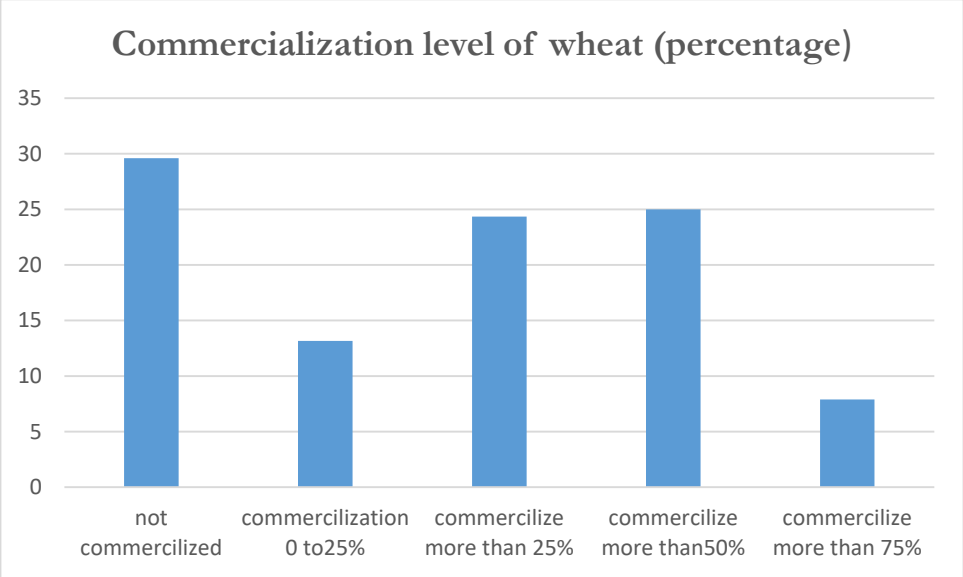



**Fig. 1.** Level of commercialization

Demographic characteristics of farmers for continuous variables are given in Table 2. The average household size is about 4.33. Households in the study area travel almost an hour to reach the nearest periodic market in the district (DNM), and about half an hour to rich to Development Agent (DA) office. Livestock owned excluding oxen averages 14.9 Total livestock unit (TLU). A household on average operates about 0.75 ha of wheat land. Households own on average more than a pair of oxen used for traction. Annual crop production per household was 2.7 tons.

**Table 2**

Mean of sample characteristics (continues variables). SD in parentheses

| | Total | | Participant | | Non participant | | T test |
|---|---|---|---|---|---|---|---|
| Variable | Mean | SD | Mean | SD | Mean | SD | |
| HCI | 0.34 | 0.27 | | | | | |
| Age(years) | 40.6 | 12.8 | 39.2 | 10.9 | 41.2 | 13.5 | 0.8 |
| Market distance (minute) | 50.5 | 38.6 | 51.5 | 38.1 | 50.05 | 39.0 | -0.2 |
| Distance to DA( minute) | 34.4 | 17.5 | 36.3 | 20.3 | 33.6 | 16.3 | -0.8 |
| Family(number) | 4.3 | 2.4 | 4.4 | 2.6 | 4.2 | 2.3 | -0.3 |
| Oxen(numbers) | 2.6 | 1.6 | 2.2 | 0.96 | 2.7 | 1.8 | 1.8* |
| Wheat land(Hectares) | 0.75 | 0.35 | 0.2 | 0.1 | 0.15 | 0.3 | 2.7*** |
| Wheat production(ton) | 2.7 | 1.4 | 2.98 | 1.43 | 2.06 | 1.04 | 3.8*** |
| Wheat sold(ton) | 1.04 | 1.1 | 1.47 | 1 | 0 | 0 | 9.9*** |

Source: Results of the authors, 2020

Table 3 shows the demographic characteristics of farmers for categorical variables. About 15% of households in the sample are female-headed. More than 63% of household heads are literate. Only 14% of households on average had taken credit. Table 2 and 3 also details the differences between selling households and non-selling households. It indicated that there is a significant difference between sellers and non-sellers in household endowments such as oxen ownership, wheat land, mobile and non-farm income.

**Table 3**

Frequency of sample characteristics (categorical variables). Percentage in parentheses

| Variables | Levels | Total | Seller | Non seller | P value |
|---|---|---|---|---|---|
| Credit | Yes | 22(14.47) | 16 (15.0%) | 6 (13.3%) | 0.80 |
| | No | 130(85.53) | 91 (85.0%) | 39 (86.7%) | |
| Sex | Men | 129(84.87) | 91 (85.0%) | 38 (84.4%) | 0.92 |
| | Women | 23(15.13) | 16 (15.0%) | 7 (15.6%) | |
| Mobile | Yes | 52(34.25) | 80 (74.8%) | 20 (44.4%) | 0.000*** |
| | No | 100(65.79) | 27 (25.2%) | 25 (55.6%) | |
| Education | Literate | 96(63.16) | 65 (60.7%) | 31 (68.9%) | 0.34 |
| | Illiterate | 56(36.84) | 42 (39.3%) | 14 (31.1%) | |
| Seeding method | Raw planting | 72(47.37) | 53 (49.5%) | 27 (60.0%) | 0.24 |
| | Broadcasting | 80(52.63) | 54 (50.5%) | 18 (40.0%) | |
| Non-farm income | Yes | 100(65.79) | 27 (25.2%) | 25 (55.6%) | 0.000*** |
| | No | 52(34.21) | 80 (74.8%) | 20 (44.4%) | |

Source: Results of the authors, 2020.

### *3.2. Econometric result*

Table 4 and 5 presents the results from maximum likelihood estimates of generalized double hurdle model of factors influencing households' decision of output market participation and commercialization. Following Gebremedhin et al. (2015); Key et al., (2000), who argues that information costs are fixed transaction costs that influence market entry, but not intensity of market participation. A mobile which indicated as fixed transaction cost has taken as exclusion restrictions in the first hurdle. The model fits the data reasonably well—about 96% of the participation outcomes are correctly predicted and the Wald test of the hypothesis that all regression coefficients are jointly equal to zero is highly rejected. For each model, the coefficient estimates as well as the marginal effects are presented. The marginal effects associated with the variables in the probit model represent changes in probability of participation. In the second-stage regression model, the marginal effects represent elasticities of observed commercialization level.

### *3.3. The first stage analysis*

Table 4 shows that result of first stage probit regression analysis. The model explains about 86 percent of the variation as indicated and most of the variables have expected sign and were statistically significant.

Regarding age of head, we see that age indeed has a U-shaped effect on the probability of being participant in market, with a positive effect kicking at age 40.6, which is about the same as the average age of the sample households. This study confirm with Abdullah et al. (2019), Pingali et al.(2005) who argued that age can often be indicative of farming experience, which makes certain informational and search costs easier and thus cheaper. This study contradicts with Alene et al.( 2008) arguing that older farmers as risk aversion and reluctance to adopt technology and hence inability to produce for the market or Chirwa and Matita (2012) arguing that older household heads are more likely to have large household sizes, increasing the food need requirements of households..

Household size also decreases market participation decisions with a 5% significance level. An increase in household size by one will decrease the probability of market participation by 5%. Gebremedhin and Jaleta (2012) indicated that household size increases domestic consumption requirements and may render households more risk-averse. Hence, controlling for labor supply, larger households are expected to have lower market orientation and market participation. Our study is in conformity with Siziba et al. (2011) but contradicts with Abdullah et al. (2019), Moti et al. (2009) who claim household labor can work at a lower cost and reduced transaction cost.

Oxen affect both equations but differently. Positively and significantly in participation decision and this is due to oxen is a source of traction for a majority of Ethiopian smallholder farmers. Our study is in conformity with Boughton et al. (2010).

Wheat land size, which can be considered as a household's wealth, has a positive and statistically significant (1% significance level) influence on the probability of market participation. On average, each additional hectare of land increases the probability of market participation by almost 10%. This result confirms that land is a key constraint input for rural households and landholding per capita is declining mainly because of a rapidly growing population. Moreover, the land market for smallholder farmers is nonexistent in Ethiopia as land is state property and farmers have only usufruct right (Woldeyohanes et al., 2017). Our result is also consistent with Olwande et al. (2015) Alene et al. (2008) Boughton et al. (2010) Makhura (2001), , Siziba et al. (2011).

**Table 4**
First stage probit result: the determinants of market participation

| | Market participation | |
|---|---|---|
| VARIABLES | Coefficient | Change in probability |

| | | |
|---|---|---|
| Age of the head (years) | -0.198** | -0.0487** |
| | (0.0843) | (0.0196) |
| Age of the head squared (years) | 0.00251** | 0.000616*** |
| | (0.000976) | (0.000224) |
| Gender of the head (women = 1) | -0.178 | -0.0437 |
| | (0.390) | (0.0956) |
| Education of the head (literate= 1) | 0.0593 | 0.0146 |
| | (0.284) | (0.0696) |
| Household size (number) | -0.213** | -0.0522** |
| | (0.0920) | (0.0215) |
| Number of oxen (number) | 0.248* | 0.0610** |
| | (0.128) | (0.0304) |
| Wheat land owned(ha) | 0.397*** | 0.0976*** |
| | (0.154) | (0.0352) |
| Off-farm income(yes=1) | -1.055*** | -0.259*** |
| | (0.274) | (0.0567) |
| Distant to wheat market (walking minuet) | -0.00110 | -0.000269 |
| | (0.00344) | (0.000845) |
| Ownership Mobile (yes=1) | 1.055*** | 0.259*** |
| | (0.272) | (0.0561) |
| Constant | 3.086** | |
| | (1.512) | |
| Pseudo R2 = 0.11 % | | |
| correct prediction overall =96.08 % | | |
| correct prediction participants = | 85.95 % | |

Note: *, **, *** represent significance at 10%, 5%, and 1% probability levels respectively. The figures in parentheses represent Standard errors

The coefficient on off-farm income is statistically significant in both equations but different in sign. It has a negative effect on the probability of farmer market participation and statistical significance at the 1% level. A farmer that has off-farm income decreases their probability of market participation by 26%. Rios et al. (2008) claimed that the relationship between off-farm income and agricultural commercialization is negative, because the available time is devoted to off-farm activities and there is less time for agricultural production and also according to Alene et al.(2008), off-farm income is conducive to commercialization if it is invested in farm improvement and technology.

The coefficients of mobile and distance to nearby markets, which are included to control for the effect of market information are significant. Mobile ownership increases the probability of market participation by 26%. Our finding is in line with Olwande et al. (2015), Siziba et al. (2011)

***The second stage analysis***

The Tobit model (second stage) is used to analyze determinant of commercialization level. The result is shown in Table 5. The correlation coefficient between residuals from the market participation and commercialization level (the coefficient of the inverse Mills ratio) is 0.747 and highly significant, indicating that the generalized double hurdle model is preferred to independent double hurdle model in this study (Cragg, 1971)

The commercialization level increases with household size, once participation decisions are made. The results show that the marginal effect of commercialization level is 0.112, implying that an increase in additional household size increases commercialization level by 11% among sellers. Our study is in conformity with (Moti et al., 2009)

Oxen has a negative and significant influence on the level of commercialization and this may be due to more oxen offer alternative financial income for the household so that marketed surplus would be lower. According to (Rios et al., 2008), owners of livestock reduce the amount of time devoted to crop production and marketing, thereby leading to lower production and lower sales.

Off-farm income has a positive effect on the commercialization level. Off-farm income increases the commercialization level by almost 57%. Perhaps participation in off-farm activities does help smallholder farmers to overcome liquidity constraints. According to Woldeyohanes et al. (2017) when agricultural growth is hampered by credit constraints, the additional resources can be used by farmers for the adoption of innovations and the purchase of input. Our finding is in line with Abdullah et al. (2019), Alene et al. (2008), Martey (2014)

**Table 5**

Second stage Tobit result: the determinants of commercialization level (HCI)

| | Level of commercialization | |
|---|---|---|
| VARIABLES | Coefficient | Average marginal effect |
| Age of the head (years) | 0.00258 | 0.0277 |
| | (0.0139) | (0.0191) |
| Age of the head squared (years) | -0.000221 | -0.000534 |
| | (0.000158) | (0.000217) |
| Gender of the head (women = 1) | -0.111 | -0.102 |
| | (0.0877) | (0.121) |
| Education of the head (literate= 1) | -0.100 | -0.154 |
| | (0.0661) | (0.0909) |
| Household size (number) | 0.0749*** | 0.112*** |
| | (0.0196) | (0.0269) |
| Number of oxen (number) | -0.0424** | -0.0488* |
| | (0.0190) | (0.0261) |
| Wheat land per capita (ha) | -0.00818 | 0.244 |
| | (0.0285) | (0.0392) |
| Off-farm income(yes=1) | 0.398*** | 0.566*** |
| | (0.0838) | (0.115) |
| Distance to wheat market (walking minutes) | -0.00191** | -0.00103** |
| | (0.000763) | (0.00105) |
| $\lambda_m$(Mills' ratio) | -0.747*** | -0.916*** |
| | (0.124) | (0.170) |
| Constant | 4.951*** | - |
| | (0.256) | |
| Correct prediction level of commercialization | 84.16% | |
| log likelihood = -280.50176 | | |
| LR chi2(10) = 62.37 | | |

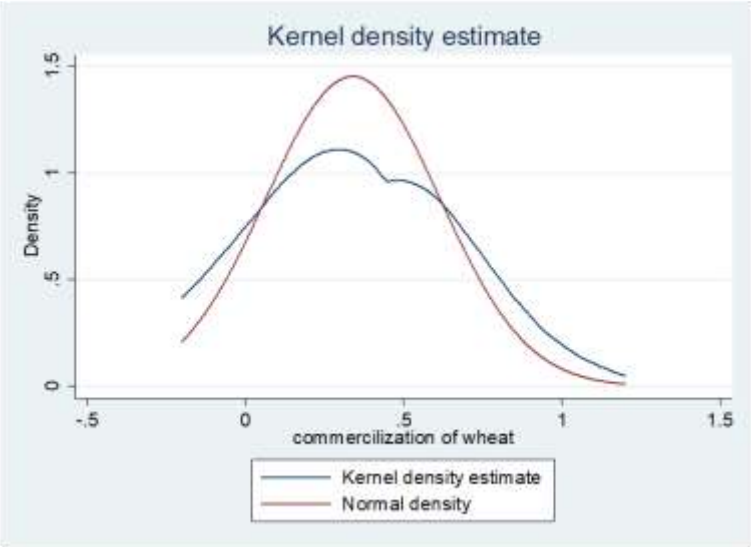
Note: *, **, *** represent significance at 10%, 5%, and 1% probability levels respectively. The figures in parentheses represent Standard errors

Conditional on the participation decision that has been made, one-hour distance from the nearest periodic market on average decreases commercialization level by 0.1%, which is statistically significant at the 10% level. According to Siziba et al. (2011) farmers located in more remote villages had less likelihood to participate in cereal markets probably because of the deterrent market access costs. Our study is in conformity with Olwande et al. (2015), Barrett (2008) Rios et al. (2008), Gebremedhin and Jaleta (2010)

## 4. Conclusion

This paper examined Smallholder commercialization of Wheat in Minjar Shenkora district, Ethiopia, using a generalized double hurdle model and data from Minjar Shenkora district in the central Ethiopia. The results show that physical capital (ownership of oxen and landholding) and market information (distance to market and mobile ownership) are the main factors influencing commercialization, these suggest that constraints to market infrastructure may be the main factors limiting commercialization. The study found the size of land owned positively influence commercialization. The findings suggest that policies that not only consider ownership of land but also the size owned is important in market participation.

**Appendix 1**.Kernel density estimate for Household commercialization index .




A limitation of the standard double hurdle specification is that it is built on the assumption of bivariate normality of the error terms. If the normality assumption is violated the maximum likelihood estimates of the model will be inconsistent. This may be particularly relevant when the model is applied to a dependent variable with a highly skewed distribution, as is often the case with survey data commercialization. As suggested by Yen and Huang (1996), one way to correct for the non- normality of the error terms consists in applying a HIS transformation to the dependent variable.

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