A Triple-Hurdle Model of the Impacts of Improved Chickpea Adoption on Smallholder Production and Commercialization in Ethiopia.

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Abstract:

Enhancing agricultural productivity through the adoption of proven technologies presents a credible pathway to economic development and poverty reduction. The adoption of improved chickpea varieties in Ethiopia has the potential to contribute not only to food security but also to economic development as well as poverty reduction among the poor. We analyze the impacts of improved chickpea adoption on smallholder production and commercialization employing a triple hurdle (TH) model on a panel data of three rounds (2008, 2010, 2014), drawn from 614 households in potential chickpea areas in Ethiopia. The correlated random effect model coupled with the control function approach for non-linear panel models was employed to address heterogeneity and endogeneity. The adoption of improved chickpea varieties shows a significant positive effect on the commercialization of chickpea. This study therefore affirms the importance of improved chickpea varieties for commercialization and additionally provides support for policies targeting poverty alleviation in rural areas through targeting more novel farm technologies, improving extension services and increasing access to land especially by the young.

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JEL Codes: Q16, Q18

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ABSTRACT

Enhancing agricultural productivity through the adoption of proven technologies presents a credible pathway to economic development and poverty reduction. The adoption of improved chickpea varieties in Ethiopia has the potential to contribute not only to food security but also to economic development as well as poverty reduction among the poor. We analyze the impacts of improved chickpea adoption on smallholder production and commercialization employing a triple hurdle (TH) model on a panel data of three rounds (2008, 2010, 2014), drawn from 614 households in potential chickpea areas in Ethiopia. The correlated random effect model coupled with the control function approach for non-linear panel models was employed to address heterogeneity and endogeneity. The adoption of improved chickpea varieties shows a significant positive effect on the commercialization of chickpea. This study therefore affirms the importance of improved chickpea varieties for commercialization and additionally provides support for policies targeting poverty alleviation in rural areas through targeting more novel farm technologies, improving extension services and increasing access to land especially by the young.

Key words: adoption, production, commercialization, triple hurdle model, control function, correlated random effect

JEL Codes: C23, C24, Q13, Q16, Q18

1 INTRODUCTION

The transition of smallholder agriculture from subsistence to market-orientation has been a core theme in the fields of development and agricultural economics over the last few decades (Barrett, 2008). The understanding of this transition from subsistence agriculture characterized by low productivity and food self-sufficiency to market-oriented agriculture characterized by high productivity marketing surplus is of utmost significance for most developing countries depending on agriculture (Wickramasinghe and Weinberger, 2013).

In Ethiopia, the agricultural sector is in the hands of smallholder farmers who mainly produce for subsistence purposes. Recognizing that subsistence agriculture will not ensure the much-needed food security and household welfare, the Ethiopian government has liberalized its economy and put in place strategies to reduce poverty. These strategies encompass market-oriented policies for the achievement of economic growth and agricultural development (Shiferaw and Teklewold, 2007) and to commercialize subsistence agriculture (Mekonnen, 2015). The current policy environment is geared at promoting the production and commercialization of high-value farm products. However, smallholder farmers are unable to benefit from such policy interventions because of low-yielding varieties, high transaction costs, lack of rural infrastructure and inadequate services (Gebremedhin and Hoekstra, 2007).

Farming in Ethiopia is still labour intensive with the use of rudimentary production tools and techniques. Nevertheless, the use of improved seeds and other improved technologies is currently receiving diverse attention and policy intervention in Ethiopia. Since its creation in 1994/1995, the Participatory Demonstration and Training Extension System (PADETES) is acting as a vehicle for driving improved techniques and innovations to farmers with goals, the development and distribution of packages of improved seeds, fertilizer, training and credit. As reported by Yu et al. (2011), it has virtually achieved its objectives by reaching all farming communities in Ethiopia. Despite resurgent interest in the adoption of improved technologies, increased adoption and transition to productivity-oriented agriculture firmly depends on opportunities available in markets (Asfaw et al., 2011). Thus the promotion of market orientation in smallholder agriculture remains a vital tool in the development of an efficient value chain that can supply food (Okoye et al., 2016). Market participation gives farmers the opportunity to exploit the benefit of comparative advantage, thereby generating surplus production that maximizes growth and generates linkages by supplying inputs thus enhancing growth and livelihood. It also enhances rural development while improving the livelihoods of the rural poor. Nevertheless, it is severely constrained in developing countries by low production which arguably results from the use of primitive and local techniques and technologies in farm production. High transportation costs further fuels non participation in markets.

The body of empirical literature on smallholder commercialization in Africa has been on the increase over the last decade. However, most of these studies employ the 'double hurdle' (DH) approach and focus on either modeling the impact of transaction costs and market failures in explaining the household's participation in output markets (Alene et al., 2008; Holloway et al., 2001; Key et al., 2000; Ouma et al., 2010) or dealing with sample selection bias when estimating market participation (Bellemare and Barrett, 2006; Ouma et al., 2010). However, as Camara (2017) demonstrates in his recent study on grain cereals in Guinea, market participation is also influenced by production side shifters such as adoption. Asfaw et al. (2011), in their study on the impact of technology adoption on the integration of farmers into output markets, found the adoption of improved agricultural technology to significantly influence output market participation.

Furthermore, Mausch et al. (2017) explore the twin challenges of profitability and resilience in smallholder agriculture through the use of modern agricultural technologies. The authors found an interesting avenue to address these seemingly opposing targets simultaneously but also outline how different technologies interact within these two spheres. Hence it will be worthwhile testing this empirically to confirm their theoretical findings. Constrained by data limitations, most studies on market participation employed cross-sectional data making causal identification difficult. To the best of our opinion, this study is the first to employ panel data in modeling the effect of improved chickpea adoption on smallholder production and commercialization in Ethiopia.

Based on the identified problem and the research gaps, the overarching objective of this study is to analyze the linkage between the adoption of improved chickpea and smallholder production and commercialization in Ethiopia while controlling for endogeneity and heterogeneity in the study sample. The specific objectives are: (1) To determine if there exists a causal relationship between improved chickpea adoption and the household market participation decision; (2) To estimate the extent by which the adoption of improved chickpea influences the quantity of chickpea sold in markets. This study adds to existing literature by (1) providing new empirical results on explaining production and market participation in

Ethiopia using a triple hurdle model, (2) offering a rigorous analysis on the causal impact of improved seed adoption in explaining production and market participation employing panel data, (3) controlling for both heterogeneity and endogeneity in non-linear panel models using the correlated random effect (CRE) model and the control function approach (CF), respectively.

The remainder of this article is structured as follows: Section 2 and 3 present the theoretical framework and the econometric approach, respectively. Section 4 gives a full synopsis of econometric results and discusses the findings. The article ends with the conclusion and policy implications in section 5.

2 THEORETICAL FRAMEWORK

The farmer decision-making process can be viewed from the standpoint of the agricultural household framework, as was adapted by Key et al. (2000) and more recently Barrett (2008) to market participation. Market participation decision usually results from the joint decision of production and consumption. Therefore, we employ the basic non-separable agricultural household model as developed by Singh et al. (1986). This model assumes that market failure for both factor and product markets make the production and consumption decisions of agricultural households non-separable (Sadoulet and Janvry, 1995; Singh et al., 1986). In the case of Ethiopia, household consumption characteristics like household demographic structure and consumption preferences affect the decision regarding production (input use, production levels, choice of activities) and subsequently marketing.

Households maximize their utility by choosing their level of consumption (c_i), production (q_i), amount purchased in the market (b_i), and amount sold (s_i), with the application of inputs (x_k) in production technology F. The household maximizes its utility subject to available income/cash constraint (2), input and output quantity balance (3), production technology (4), with the market prices (5) and lastly non-negativity constraints (6).

$$\text{Max}_{c_i, q_i, b_i, s_i, x_k} \; U(c, z_u) \tag{1}$$

Subject to

$$\sum_{i=1}^{N} p_i^m (s_i - b_i) - \sum_{k=1}^{M} p_k X_k + Y \geq 0 \tag{2}$$

$$q_i - x_i - c_i + b_i - s_i + E_i = 0 \tag{3}$$

$$F(q, x : z_q) \geq 0 \tag{4}$$

$p_i^m\ is\ given$ (5)

$c_i, q_i, b_i,\ x_k, s_i\ \geq 0$ (6)

$i = 1, \dots . N\ and\ k = 1, \dots M$

Where p_i^m is the market price of product i, E denotes endowments, z_u and z_q are a vector of household and production characteristics respectively, Y is transfers and other incomes while F represents the production technology of the household. The available income constraint states that the revenue from sales and other transfers must be greater than or equal to the expenditure from household purchases and inputs used in production. The input and quantity balance (3) suggests that the total quantity consumed, used as input and sold in the market cannot exceed the quantities produced, bought and the endowment of the household. The production technology constraint refers to a production function that is well-behaved and relates all physical inputs to physical output considering other production shifters, z_q.

The above utility maximizing framework is only valid in the absence of transaction costs (TC). However, recent empirical studies have demonstrated the role of transaction cost in explaining the autarkic behavior of farmers (Alene et al., 2008; Barrett, 2008; Burke et al., 2015). TC includes transportation costs and the consequences of imperfect and asymmetric information (Sadoulet and Janvry, 1995).

Let us assume a selected household faces transaction costs $t_i^c\ (A,\ G,\ Z,\ Y)$ for trading in the market at a price p_i^m for each good i. Transaction costs can either be proportional transaction cost (PTC, t_i^p) or fixed transaction cost (FTC, t_i^f). These costs are jointly dependent on asset holding, A (land, labour, improved seeds, livestock holding and transport vehicles), vector G (extension service and farmer associations, access to road) as well as household characteristics (e.g age, gender, education, experience etc.), represented by the vector Z and liquidity Y which reflect transfers and other income sources. Transaction cost is incorporated in the cash constraint of the agricultural household model framework as shown below:

$$\sum_i \left[\left(s_i \left(p_i^m - t_i^p \delta_i^s\right) - t_i^f \delta_i^s\right) - \left(b_i \left(p_i^m + t_i^p \delta_i^b\right) - t_i^f \delta_i^b\right)\right] - \sum_{k=1}^{M} p_k X_k + Y = 0 \quad (7)$$

Where δ_i^s equals 1 if the household sells and 0 for autarkic households, δ_i^b equals 1 for buyer households and 0 otherwise. Here we note an important condition which states that for the same period, a household cannot assume both the buying and selling status.

$\delta_i^s + \delta_i^b \leq 1$ (8)

In this constraint, we can conclude that in the presence of transaction costs (t_i^f and t_i^p), the market price for both buyers and sellers change by the value of the transaction cost: for buyers, the market price increases while it reduces for sellers.

The output market participation intensity conditional on market participation can be obtained by taking the first order conditions of the maximization problem (Key et al., 2000) and is expressed as:

$$q_{sj}^p \;= f\left(p_i^m, z, G, Y, x_k, t_i^f,\; t_i^p A, z_q\right) \tag{9}$$

Where q_{sj}^p is the households' decision to participate in the market and conditional on this, the intensity of the market participation decision is expressed as

$$q_{sj} = f\left(p_i^m, G, Y, x_k, A, t_i^p, z_q\right) \tag{10}$$

From the above, market participation decision is affected by production technology, transaction costs, market prices, access to extension training and government support services, available income sources, household endowments and household demographic characteristics. The market intensity decision, on the other hand, is affected by the same factors but for the fixed transaction costs since farmers will be able to trade any volume after paying search and bargaining costs.

For the first tier, in order to select the optimal production decision that maximizes the utility objective, we differentiate the lagrangian function with respect to production (q_i).

The empirical model specification directly flows from the reduced form equations identified from the above theoretical framework. The choice of the explanatory variables used in the study to tackle production and commercialization is based on theory and from past studies (Boughton et al., 2007; Burke et al., 2015; Gebremedhin et al., 2017; Mekonnen, 2015;

Okoye et al., 2016; Woldeyohanes et al., 2017).

3 ECONOMETRIC APPROACH

Most empirical studies on market participation have profiled the participation of households into output markets as a two-stage decision process and either employed a sample selection model such as the Heckman's sample selection (Alene et al., 2008; Bellemare and Barrett, 2006; Boughton et al., 2007; Ouma et al., 2010) or a corner solution model (endogenous switching regression models, restrictive Tobit model and the double hurdle model) (Camara, 2017; Goetz, 1992; Omiti et al., 2009; Woldeyohanes et al., 2017). The DH approach starts modeling from production and implicitly assumes all households in the study area are either producers or potential producers. This assumption can be true if more than two crops are considered in the model. However, in essence, not all households are always producers as is the case with our study where just 4/5 of the household are into chickpea production. It is therefore important to model all households (both producing and non-producing) as any policy which encourages producers to market may also induce non-producers to begin producing and also participate in markets (Burke et al., 2015). A flexible extension of the DH called the triple hurdle (TH) models such relationships by including an additional tier for the production decision. To this end, MP studies are beginning to take the form of a TH model (Gebremedhin et al., 2017; Okoye et al., 2016) after the pioneering work of Burke et al. (2015) on milk production and MP in Kenya. Inspired by a major limitation of the DH which only modeled producer households, they introduced the triple hurdle (TH) model which includes an initial stage of production to capture non-producers. Therefore, for the analysis of smallholder chickpea production and MP in Ethiopia, we employed the 3- stage or TH model.

Starting from all the surveyed households, in the first stage we estimate the decision to produce chickpea using a probit regression. In the second stage, a probit regression is still used to estimate market participation decision by the producer households. Finally, conditional on participating in the market as a seller, the level of participation (quantity sold) is estimated using a truncated normal regression.

Mathematically the three stages in the TH model can be expressed as:

Decision to produce chickpeas by a given household i at time t

$$p_{it}^{p*} = \boldsymbol{\lambda w}_{\boldsymbol{it}}^{'} + c_{i1} + \varkappa_{it}$$

$$p_{it}^{p} = \begin{cases} 1 & if\ p_{it}^{p*} > 0 \\ 0 & otherwise \end{cases} \qquad (11)$$

Decision to participate in market:

$$y_{it}^{p*} = \boldsymbol{\alpha x}_{\boldsymbol{it}}^{'} + \omega d_{it} + c_{i2} + \varepsilon_{it}$$

$$y_{it}^{p} = \begin{cases} 1 & if\ y_{it}^{p*} > 0 \\ 0 & otherwise \end{cases} \qquad (12)$$

Decision on the quantity to sell:

$$y_{it}^{*} = \boldsymbol{\beta v}_{\boldsymbol{it}}^{'} + + \eth d_{it} + c_{i3} + \mu_{it}$$

$$y_{it} = \begin{cases} y_{it}^* & if\ y_{it}^* > 0\ and\ y_{it}^p = 1 \\ 0 & otherwise \end{cases} \quad (13) \quad ; \begin{matrix} i = 1,2 \ldots., N \\ t = 1,2 \ldots., T \end{matrix}$$

Where p_{it}^{p*}, y_{it}^{p*} $and\ y_{it}^*$ are latent variables representing the probability to participate in chickpea production, market and the potential marketed quantity respectively. Equation (11) signifies the probability of producing chickpea, and it is a binary choice of whether to produce chickpea or not. It can take the value 1 if the household produces chickpea or 0 otherwise. Equation (12) also signifies the probability of participation in the market, and it is a binary decision of either participating as a seller in the output market or not. It takes the value of 1 if the household participates in the market or 0 otherwise. Equation (13) represents the level of market participation which is the decision of the number of shares to sell in the market (actual amount sold in the market). The dependent variable is measured as the marketed quantity of production of chickpea by the various farming households. d_{it} represents the main covariate, the cultivation of improved chickpea varieties. It is a dummy and assumes the value of 1 if the household planted this improved varieties or zero otherwise. Its coefficient estimates of ω and ð give the effect of improved chickpea adoption on market participation and intensity of market participation respectively. $\boldsymbol{w_{it}}$, $\boldsymbol{x_{it}}$, and $\boldsymbol{v_{it}}$ represent vector exogenous variables that affect the likelihood of chickpea production, the probability of selling in the market and the marketed surplus of chickpea farmers respectively with $\boldsymbol{\lambda}$, $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ representing the corresponding vector of parameter estimates.

As shown above, there are two types of errors exhibited in the models. Firstly, we have unobserved time-invariant factors (c_{i1},c_{i2}, c_{i3}) in equations (11), (12) and (13) respectively. These are individual characteristics that affect the household's decision to produce, market and the quantity of chickpea to sell but are unobserved. It is usually referred to as unobserved heterogeneity and tough to measure because of its qualitative nature. Secondly, we have the idiosyncratic error or time variant error ($\varkappa_{it}$, ε_{it},μ_{it}) which are unobserved factors that change over time and affect p_{it}^p , y_{it}^p, and y_{it} respectively. They are briefly addressed below.

3.1 Unobserved Heterogeneity ($\boldsymbol{c_i}$)

There is the prevalence of household heterogeneity that influences production and commercialization but is not observed. This unobserved heterogeneity is time-invariant and usually include characteristics like motivation, risks, talents, choice, and abilities that vary across individuals and households. To obtain unbiased and consistent estimates for nonlinear panel models, the covariates must be independent of unobserved heterogeneity. This assumption is rather strong and needs to be taken care of to get unbiased and consistent estimate. Correlated random effect model (CRE) as pioneered by Mundlak (1978) and relaxed by Chamberlain (1984) is the best approach to relax this assumption of no correlation (Ricker-Gilbert et al., 2011; Woldeyohanes et al., 2017). It does this by specifying that the correlation assumes the form of $c_i = \tau + \overline{X}_i\xi + a_i$, where $\overline{X}_i$ signifies the time average of all time variant regressors in equations (11), (12), and (13) above, τ and ξ are constants and a_i is the stochastic error term. Practically, this is very similar to the random effect (RE) model but with the addition of time averages of all time-variant covariates. It is the addition of $\overline{X}_i$ that controls for the correlation between c_i and x_{it}.

The advantage of this approach is that it is a flexible extension to the RE model as it relaxes the orthogonality condition[1]. Moreover, even though we estimate with the RE estimator, we obtain fixed effect estimates for the time invariant heterogeneity while avoiding the incidental parameters problem for non-linear models. Furthermore, CRE can be easily combined with the control function approach for non-linear models with both heterogeneity and endogeneity.

3.2 Endogeneity

Some of the covariates in equations (12) and (13) above are potentially endogenous and need to be controlled for. This is more evident for our key variable adoption. The heterogeneity of households regarding asset holdings, institutional and public service, information access and other observed and unobserved factors may possibly affect both the market participation decision and the quantity to sell as well as adoption. Hence adoption is seemingly endogenous in the commercialization hurdles. Moreover, there exists potential simultaneity between adoption of the improved technologies and commercialization. While increased adoption could lead to market participation through higher yields, commercialization on the other hand may result in adoption through higher incomes making it possible to easily obtain the improved seeds. In this case, adoption may be highly correlated with unobserved time variant shocks. The same is also true for the quantity of chickpea produced being part of the household decision making process. It is also potentially endogenous as a result of the non-separability between production and consumption decisions of farm households. Most households will only supply to the market after satisfying household consumption demands.

[1] Orthogonality condition refers to zero correlation between c_i and x_i

So there exists the possibility for correlation in the error terms for both production quantity and commercialization.

There are two approaches to address endogeneity: the widely used two-stage least squares (2SLS) and the control function (CF). For non-linear models, the CF is more appropriate and offers some distinct advantages. First, it addresses endogeneity by adding a new variable to the regression, which produces precise and accurate estimates and secondly, it leads to a straightforward exogeneity test for such models (Wooldridge, 2015). The CF employs a two-step procedure wherein a probit model is used to estimate the reduced form equation for adoption. The selection of a valid instrument is an arduous task because of the two known conditions of relevance and exogeneity which refers to the inclusion and exclusion restrictions respectively. The input cost which comprises the cost of the improved seeds is used as an instrumental variable in the reduced form for adoption. This is because farmers will not adopt these improved seeds if the price of the seed is too high. Moreover, input cost affects MP only through adoption. For the reduced form for the quantity of chickpea produced, we employ the tobit model because of the censored nature of quantity produced as some farmers reported zero production. Total labour is used as the exclusion restriction here because of its unconditional relationship with commercialization. For purposes of robust identification, the quantity of chemical fertilisers and an interaction of the regional districts with the cultivated area is also used. For all the reduced forms, we also include other covariates and the means of time variant variables to control for unobserved heterogeneity.

3.3 Data

For this study, three rounds of panel data collected in the years 2007/08, 2009/10 and 2013/14 from the East Shewa Zone of Amhara and Oromia Region of Ethiopia are used. Shewa is located in the northeast of Bishoftu (50km south-east of the capital Addis Ababa). The survey was carried out in two stages: Firstly, a reconnaissance visit was undertaken wherein production and marketing conditions of the area was understood through discussions with farmers, traders and extension officers in the area. The findings from the visit were used to refine the survey instrument and the sampling methods. Secondly, a formal and better survey instrument was prepared, and enumerators trained to collect information through an oral interview with the households. Three districts were purposely selected using multistage sampling from regions with suitable agro-ecology, high intensity of chickpea cultivation and easy accessibility. These districts (Minjar-Shenkora, Gimbichu, and Lume-Ejere) represent the main areas where farmers are adopting the new Kabuli chickpea varieties. In each of the districts, 8-10 villages were selected randomly and 150-300 households also randomly chosen from the villages. In total, 700 farm households were then surveyed with the aid of a standardized survey instrument. This makes the analysis not a representation of the whole nation and hence should only be understood as an upper bound of the improved chickpea adoption impacts on production and commercialization in Ethiopia. For the three panel years, 700, 661 and 631 households are surveyed respectively in the three rounds. The analysis makes use of a balanced sample of 614 households giving an attrition rate of 12.2%. This attrition rate is both relatively and reasonably low when compared to other integrated household surveys in developing countries which may record up to 25%.

3.4 Variable Description

Table 1 presents the summary statistics of the pooled data for continuous variables while Table 2 shows the frequencies and percentages of the indicator variables. There are 1842 households in the pooled data of which 67.3% are net sellers. The pooled data shows 81.98% of households are into chickpea production with an average of 1189.30Kg. Market participation which is captured as a double fold decision with the first stage being the participation decision and the second stage being the sales quantity indicates that 67.3% of households participate in markets as net sellers and sell on average 505.34Kg of chickpea.

The main explanatory variable, adoption is captured as a dummy with the value of 1 if the household cultivates the improved Kabuli variety and 0 otherwise. Age is captured as the household's head age measured in years, and it averaged 49.2 years. Gender which is also an important variable for adoption studies is not left out with 93.1% of the households being male-headed. Education of the head of household is proxied as the number of years spent in any level of schooling. It has an average of 1.84 years implying most farmers in the region are not educated. Farmers have farming experience ranging from 0-69 years with an average of 22.13 years indicating that most farmers are longtime cultivators of chickpea.

Household income which refers to the amount of earnings a household possesses and off-farm income is captured in US dollars though measured in the local currency, ETB. Average household farm income and off-farm income are 7572.25USD and 379.60USD respectively showing that off-farm income contributed very little to household income. The total value of the household's assets is also proxied with an average value of 853.7USD per household. Included in the household assets are agricultural, transport and information- like related assets of the household like mobile phones and radios. Input costs made up of the costs of improved seed, chemical fertilisers and other variable cost items had an average value of 1932.03USD. Farmers also made use of chemical fertilisers in their production. Fertiliser usage has a mean value of 482.39Kg/ha. As compared to other crops, this is pretty low. Nevertheless it is important to note that chickpea being a leguminous crop, aids in synthesizing atmospheric nitrogen which is taken up by other cereals like teff and maize.

Area of cultivation is also taken into consideration and captured as both total area of cultivation of all crops and area attributed to the cultivation of improved chickpea, all in hectares (ha). It has an average of 4.09ha and 0.58 ha respectively with the improved seed quantity used averaging 68.64Kg/ha. Labour which comprises the total family labour is reported in man-days with an average of 172.7mandays per year. The amount of livestock owned by different households is recorded using the tropical livestock unit (TLU). The TLU is estimated with the aid of FAO conversion factors for Ethiopia where one sheep equals 0.10unit; one cattle equals 0.70units, etc.

Institutional variables which have to do with the farmer's proximity to clubs and extension services and various transaction costs variables as well as the market price of chickpea are also captured. Average distance to the nearest cooperative is 2.9km implying that the farmers are surrounded with cooperatives. The mean walking distance to the main market was 8.94km, ranging from 0 km to 29km indicating that households are very close to output markets. The average transportation cost to the market is 5.53ETB[2]. Market prices for both improved and local varieties of chickpea are calculated and aggregated at a district level for consistency and managing missing values for non-sellers. Lastly, regional dummies for Lume-Ejere, Minjar–shenkora and Gimbichu districts were created and added as explanatory variables since expectations are rive that agro-climatic conditions and geographical differences affect production and market participation decisions.

Table 1: Distribution and summary statistics of continuous variables (N=1842)

Variable	Mean	Min	Max	Std. Dev.
Quantity sold (Kg)	505.34	0	12100	797.48
Head age (years)	49.12	20	85	49.13

[2] ETB (Ethiopian Birr)= ethiopian currency, 1USD=27.08ETB in October 2017

Head education (years)	1.84	0	14	2.65
Experience (years)	22.13	0	69	13.07
Household income (USD)	7572.25	0	365932.30	11272.35
Off-farm income (USD)	379.60	0	27472.53	1443.76
Total production (Kg)	1189.30	0	13700	1411.589
Area of cultivation (ha)	4.09	0	36.22	2.60
Area of improved cultivation (ha)	0.58	0	11.33	0.79
Total value of assets (USD)	853.73	0	30865.93	1967.28
Input cost (USD)	1932.03	0	17458.92	1732.46
Fertiliser (Kg)	482.39	0	5851.5	406.56
Labour (mandays)	172.74	0	2049	123.16
Livestock owned (TLU)	5.43	0	27.6	3.37
Distance to cooperative (Km)	2.90	0	34	3.05
Distance to main market (Km)	8.94	0	29	5.88
Transport cost to market (USD)	5.53	0	700	17.25
Market price of improved variety (USD)	1.93	1.75	2.07	0.12
Market price of local variety (USD)	1.17	1.05	1.58	0.21

Table 2: Summary statistics of Indicator variables (N=1842)

Variable	Yes (1)		No (0)	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Market participation	1240	67.32	602	32.68
Adoption	1149	62.38	693	37.62
Gender	1715	93.11	127	6.89
Lume ejere	768	41.69	1074	58.31
Minjar Shenkora	681	36.97	1161	63.03
Gimbichu	393	21.34	1449	78.66

Source: Own calculation based on 2008, 2010, and 2014 ICRISAT survey data.

4 RESULTS AND DISCUSSION

Testing for the endogeneity of adoption and quantity produced using the CF approach, we estimated reduced-form equations (results are under appendix) to obtain residuals for both adoption and quantity produced. Unlike in linear models where there exist some tests for strong instruments like the partial correlation between the endogenous covariate and the instruments, there are no developed tests for strong instruments in non-linear models. The best option is to look at the partial correlation in the reduced-form model. Our instruments have a very significant relationship ($p<0.01$) with the two endogenous variables. Thus, we are confident of the strength of our instruments in controlling for the endogenous variables.

The p-value for the second hurdle indicates that the residual coefficient of both adoption and quantity produced are not significant as shown in table 3 below. For the third hurdle, the residual coefficient for adoption is highly significant while production quantity is not significant. Therefore, we included the residual term for adoption in the third hurdle as an additional covariate to control for endogeneity.

Table 3: Test for endogeneity of adoption and quantity produced

	Coefficient	P-value	Conclusion
Hurdle 2 MP decision			
Residual for adoption	-0.01601	0.899	Exogenous
Residual for quantity produced	0.00012	0.347	Exogenous
Hurdle 3 Sales level			
Residual for adoption	379.589	0.006	Endogenous
Residual for quantity produced	- 0.00600	0.960	Exogenous

Source: Own calculation based on 2008, 2010, and 2014 ICRISAT survey data.

4.1 Factors affecting the decision to produce chickpea in Ethiopia

Table 4 presents the maximum likelihood estimates of the first tier of the triple hurdle model. The likelihood ratio test indicates that the slope coefficients for these participation decisions are significantly different from zero.

Table 4: Probit model of the factors influencing the probability of chickpea production in Ethiopia

Variable	Average Partial Effect (APE)
Head age	-0.00237**
	(0.00101)
Head gender	0.07349**
	(0.03645)
Input cost	-0.00001**
	(9.71e-06)
Head education	-0.00636
	(0.00407)
Distance to main market	-0.00097
	(0.00270)
Distance to cooperative	-0.00637**
	(0.00324)
Experience	0.00159*
	(0.00092)
Area of cultivation	0.0412***
	(0.01460)
Lagged market price	0.03970
	(0.04432)
TLU	0.01437*
	(0.00761)
Family labour	0.00020
	(0.00015)
Lagged rainfall	0.00021
	(0.00015)
Lume-ejere[†]	0.12425***
	(0.03468)
Minjar-shenkora[†]	-0.11692***
	(0.03631)
Year 2014[‡]	0.12423***
	(0.02310)

Log likelihood	-460.229
$\chi 2$	0.0000
Number of observations	1228
Pseudo- R^2	0.1964

Notes: ***p<0.01, **p<0.05, *p<0.1

APE is obtained using the margins command in Stata, and the standard error (in brackets) are obtained by the delta method.

†Gimbichu region is excluded from regression and used as a control.

‡2008 survey data are excluded from regression and used for comparisons.

Source: Own calculation based on 2008, 2010, and 2014 ICRISAT survey data.

The coefficient for age was expectedly negative and significant at the 5% level of probability. This indicates that younger farmers are more likely to produce chickpea than older farmers. This can be explained from the labour intensiveness of chickpea production which is usually very tiring and energy consuming for older farmers. Furthermore, as Awotide et al. (2013) reported, younger farmers are less risk averse and more receptive to new ideas and innovations than older farmers.

Gender depicted a positive relationship and was significant at the 5% level. Households which are male-headed are more likely to engage in chickpea production than female-headed households, with the male-headed households having a 7.3% likelihood of producing chickpea more than female-headed households. This is most probably due to the various labour intensive activities involved in the cultivation of chickpea like land preparation, planting, weeding, and harvesting. Furthermore, male farmers are better networked in the society which makes them get new production techniques than their female counterparts. Perhaps male farmers also have more access to land and other productive farm resources than female farmers.

The price of inputs had the expected inverse relationship with the probability of chickpea production in the study area. This mainly includes the cost of the improved Kabuli varieties. This goes to confirm that farmers will only adopt an improved technology if it is both affordable and accessible. Distance to cooperative was statistically significant at the 10% level of probability and had the expected negative impact on the likelihood of chickpea production. Understandably, this is due to the role of cooperatives as an educational and informational platform. Also, farmers in cooperatives are better placed to receive free extension trials and on-farm demonstrations from extension agents and researchers.

The number of years in cultivating chickpea (experience) increases the likelihood of chickpea production. Experience increases social networks while building self-trust and knowledge base. This positive relationship is probably due to the role of chickpea as a second crop, protein source food, ability to fix atmospheric nitrogen and its great potential for exports. Faced with such benefits especially the provision of food, farmers will be more motivated to continue cultivating chickpea.

Apart from crop cultivation, most farmers in Ethiopia are into other off-farm activities like rearing animals. Hence, it is no surprise that the Tropical Livestock unit (TLU) had a positive relationship with the probability of producing chickpea. This is intuitive as most subsistent households are gradually viewing their farming from a commercial viewpoint and not just as a 'way of life'. Because of this new perspective, they diversify their enterprises to reduce risk should any of the enterprises fail. Perhaps ownership of livestock promotes chickpea production through capital investment as it assists farmers to overcome their liquidity constraints. Land which is the key input for agricultural production was highly significant at the 1% level of probability and positively associated with the likelihood of chickpea production. Economically, the ownership of any additional hectare of land by a household increases the likelihood of that household cultivating chickpea by 4.03%.

4.2 CRE estimates of the determinants of market participation and intensity of participation

Table 5 presents the average partial effects of the various variables influencing the household decision to sell in the market and the expected quantity of sales conditional on participation. The log likelihood test shows the slope coefficients are also significantly different with respect to the producer's decision whether to participate in the market as well as with respect to the expected quantity of chickpea sold in markets.

The coefficient for adoption of improved chickpea is expectedly positive and significantly related to the MP decision. The economic effect depicts that, on average, adoption of an improved chickpea variety leads to an increase in the likelihood of the household participating in markets by 8.2%. Conditional on participation in the market, adoption of improved chickpea also depict a positive and significant relationship ($p<0.05$) with the quantity of chickpea sold in the market. This by itself makes sense because adoption will lead to higher yields which will flow to the markets after satisfying home consumption. This is consistent with expectations and previous studies (Alene et al., 2008). This empirical finding is also in accord with the hypothesis that increased adoption leads to greater market participation through increased production which is first geared for consumption purposes and later for marketing purposes. Younger farmers like in the production decision hurdle were observed to have a positive and significant relationship with the expected sales of chickpea in markets. Again, this can be attributed to their active participation in social groups, less risk averseness, and their increased concern for better livelihoods.

Although insignificant in the market participation hurdle, household education depicted a positive and significant effect on the marketed surplus of chickpea. This is attributed to the fact that education reduces search costs and increases the processing of information, hence reducing the fixed transaction cost. Education also increases social network which is vital as well for information access. Conditional on producing chickpea, the household income coefficient was found to be positive and highly significant at the 1% level of probability. This further substantiates the notion that household income is a crucial determinant of market participation. This by itself is conclusive because, with available income, households can cater for all their transaction costs and easily participate in output markets.

Regarding the area of cultivation, the results indicate that smallholder marketed surplus is positively impacted by the area of cultivation available. This shows that any increase in the area of land available for cultivation increases the expected quantity of chickpea being sold in markets conditional on participating in the market. This can be explained through increase in production which will be supplied to markets once household food demands are met. Similar results were obtained by Bellemare and Barrett (2006) who studied the market participation of livestock farmers in Kenya and Ethiopia. This finding confirms that despite the declining agricultural land per capita as a result of rapid population growth in Ethiopia, any land put into cultivation leads to more participation in markets.

Conditional on participating in the market as a seller, the coefficient of off-farm income was found to be negative and highly significant at the 1% level of probability. This suggests that the more the earnings from an off-farm activity, the lesser the quantity the household will sell in the market. Households that engage in a more profitable off-farm activity can earn higher income and increase their consumption of both agricultural and non-agricultural goods. That household would want to concentrate on increasing its off-farm income, thereby relaxing its financial constraints. This is most often the case if off-farm income is intended for consumption rather than investing to develop the farm sector, thus making it compete for resources with the farm sector. This lowers the production quantity and the quantity sold in markets. This finding in line with Woldeyohanes et al. (2017) who studied the role of off-farm income on smallholder commercialization in Ethiopia. Studies on smallholder farmers in Kenya by Alene et al. (2008) and Omiti et al. (2009) also support this finding.

Surprisingly and against theory and *a priori* expectations, total household asset value is negatively related to the decision to sell in markets. Total household asset comprise most transport assets like bicycles, motorized vehicle, tractors and information assets like phones, radios and televisions all valued in dollars. Most households turn to use these assets for other livelihood options which to them are more profitable than participating in output markets. However, conditional on the household participating in the market as a seller, a positive and significant relationship at the 1% level of significance is observed. Similar results were obtained by Boughton et al. (2007) who showed that the asset holding of a household has a crucial role to play when it comes to marketed surplus. Most of these assets tend ease transportation of farm produce to the markets, thereby downplaying the effects of transaction costs. As expected, total production depicted a positive relationship with both commercialization hurdles and was significant at the 1% significance level. This is suggestive of the fact that total production is part of the household's decision on the commercialization of chickpea. Hence on average for one kg additional quantity of chickpea produced, the quantity of chickpea sold in the market will increase by 0.6Kg, all other factors kept constant.

Based on the regional dummies, households in Lume-ejere and Minjar-shenkora were found to be positively related and highly significant ($p<0.01$) with the volume of chickpea sold in the market. This could be because the agro-ecological zone favours the production of chickpea. More so, this can be attributed to the high intensity of chickpea production in the area. Lume-ejere is located along the main interstate highway and close to the chickpea multiplication center. Farmers in this region must have benefited from pre-extension trials and on-farm demonstrations. With regards to the year dummies, there was a higher preference by farmers to sell their crops in the years 2010 and 2014. This indicates increasing market integration in the recent years. It can also be attributed to the knowledge gained on the importance of commercializing smallholder agriculture from interaction with early adopters who began selling in output markets.

Table 5: CRE model of chickpea market participation and volume of sale

Variable	Chickpea MP (APE)	Sales volume (CAPE)
Plant improved	0.08272***	478.266**
	(0.02874)	(232.335)
Head age	0.00097	-10.0039**
	(0.00086)	(4.38196)
Head gender	-0.60062	138.635
	(0.04493)	(195.677)
Head education	-0.00360	39.2243**
	(0.00335)	(17.4266)
Household income	3.73e-07	-0.00232
	(6.31e-07)	(0.00551)
Distance to main market	-0.0097	-14.8701
	(0.00231)	(11.9943)
Area of cultivation	-0.00649	87.9248***
	(0.00653)	(29.7124)
Market price	-0.02935	-211.425
	(0.03343)	(163.459)
Off-farm income	6.70e-06	-0.10076***
	(8.80e-06)	(0.03793)
Livestock owned	-0.00045	24.1584
	(0.00670)	(24.7524)
Total household asset	-0.00001**	0.10104***
	(6.43e-06)	(0.02850)
Total production	0.00011***	0.60465***
	(0.00001)	(0.04571)
Lume-ejere†	0.04045	970.546***
	(0.03107)	(252.985)
Minjar-shenkora†	-0.00805	1007.066***
	(0.03821)	(193.219)
Year 2010‡	0.10390***	397.535***
	(0.02617)	(140.823)
Year 2014‡	-0.005680	503.728***

	(0.03028)	(194.865)
Residual for adoption		379.284***
		(138.360)
Sample size	1510	1237
Pseudo- R^2	0.1259	
Log-likelihood	-623.770	-9109.37
χ^2	0.0000	0.0000

Notes: ***p<0.01, **p<0.05, *p<0.1

CAPE is obtained using the margins command in Stata, and the standard error (in brackets) are obtained by the delta method.

†Gimbichu region is excluded from regression and used as a control.

‡2008 survey data are excluded from regression and used for comparisons.

Source: Own calculation based on 2008, 2010, and 2014 ICRISAT survey data.

5 CONCLUSION

Despite advances in the theoretical analyses of smallholder commercialization in Africa, little attention has been placed on the impact of improved technology adoption. Most studies focused on the role of both fixed and variable transaction cost on smallholder commercialization as well as the role of household asset holdings. Therefore in this study, we argue that smallholder commercialization does not depend only on an efficient output market but also on the availability of improved technologies and other production shifters. Using a three-period panel data collected by the International Crop Research Institute for the Semi-arid Tropics (ICRISAT) in 2008, 2010 and 2014, we employ the basic non-separable agricultural household model to estimate a triple-hurdle model of production, market participation and quantity of sales. We use a balanced sample of 614 households and employ the correlated random effect (CRE) model and the control function (CF) approach to control for both unobserved heterogeneity and endogeneity in our panel data.

Rigorous econometric analysis shows the positive impact of improved chickpea adoption on smallholder production and commercialization in Ethiopia. Adoption positively impacted commercialization by increasing yields and generating marketed surplus. This finding support the hypothesis that improved chickpea adoption significantly influences smallholder commercialization in Ethiopia. Thus, this study urges policy to target the development of novel technologies like improved seeds and other techniques in Ethiopia. To increase the adoption of improved varieties, extension services should be strengthened and the improved seeds made accessible and affordable to farmers. Extension agents should pique the interests of farmers through on-farm demonstrations, farm training, and test trials.

Other factors, which significantly influenced the decision to produce chickpea are gender, input cost, distance to cooperative, farmer experience, area of land cultivated, market price and TLU. The decision to sell in output markets is influenced by the total asset holding of the household and the total quantity of chickpea produced. Finally, the quantity sold in the market conditional on participation is driven by household head's age, education, area of cultivation, the price of chickpea, off-farm income, total asset holding and the total quantity of chickpea produced. As a result, initiatives focusing on increasing the yield level of farmers should be supported since higher yields drives commercialization. The difference in agro-ecological zone also influenced production and commercialization.

Another key finding was that younger farmers were observed with a greater probability of chickpea production and a higher degree of commercialization than their older counterparts. Policy efforts that support younger farmers in their access to modern inputs and other services may help increase smallholder commercialization. There should be increased access to land by the rural youths as they are migrating out of agriculture as a result of land scarcity and restrictions in land markets (Bezu and Holden, 2014).

Finally, to encourage market participation, interventions in Ethiopia should particularly focus on improving the access of households to land. This is because findings show that the greater the area of land cultivated, the greater the output and the willingness to participate in output markets and sell more. However, agricultural land is declining in Ethiopia due to pressure on land by its growing population.

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Appendix A

CRE estimates of the factors influencing the decision to plant improved varieties

Variable	**Coefficient**
Input cost	-0.00009***
	(0.00003)
Rainfall	0.00012
	(0.00058)
Head age	-0.00656**
	(0.00294)
Distance to market	-0.01765***
	(0.00630)
Head education	0.01236
	(0.01411)
Distance to extension agent	0.00214

	(0.02219)
Area of cultivation	0.01509
	(0.02756)
Off-farm income	-0.00001
	(0.00003)
Number of crops grown	0.19260***
	(0.03210)
Owns agricultural machinery	0.29833
	(0.60549)
Year 2010	0.58954***
	(0.08741)
Year 2014	1.41252***
	(0.11449)
Lume-ejere	1.28241***
	(0.09694)
Minjar-shenkora	0.56252***
	(0.09256)
Constant	-1.70295*
	(0.87613)

Source: Author's computation from 2008, 2010 and 2014 ICRISAT survey data

Appendix B

CRE estimates of the factors influencing production quantity

Variable	**Coefficient**
Input cost	0.11665***
	(0.03203)
Head age	-16.395***
	(3.2415)
Head Gender	109.751
	(120.905)
Distance to market	-7.0968
	(7.7827)
Distance to cooperative	-19.1549**

	(9.49442)
Chickpea experience	6.15030
	(3.0146)
Head Occupation	25.1044
	(24.3120)
Irrigation	21.2817
	(231.161)
Area of cultivation	85.226***
	(31.310)
Soil Water	-40.0338
	(58.8026)
Chemical Fertilizer	-0.66026
	(0.11776)
Total labour	0.81690**
	(0.37310)
Experience	-0.38541**
	(2.28453)
Fertilizer	-0.26118***
	(0.16267)
TLU	58.005***
	(17.572)
Year 2010	-436.666 ***
	(77.547)
Year 2014	-88.2693
	(99.079)
Lume-ejere	-159.376***
	(146.779)
	(89.8477)
Minjar-shenkora	-212.691
	(151.944)

Interaction of area of cultivation with regional districts	
Lume-ejere	225.189
	(28.1286)
Minjar-shenkora	-11.5050
	(33.0177)

Author’s computation from 2008, 2010 and 2014 ICRISAT survey data