Ethiopian Economics Association

(EEA)

PROCEEDINGS OF THE THIRD ANNUAL CONFERENCE OF THE TIGRAY REGIONAL STATE ECONOMIC DEVELOPMENT

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Published: May 2015

ISBN – 978-99944-54-43-3

FOREWORD

The Ethiopian Economic Association (EEA) and its Mekelle Chapter are happy to issue the proceeding of the Third Annual Conference on the Tigray Regional State Economic Development which was organized on June 28, 2014 at Axum Hotel Conference Hall, Mekelle. EEA co-organized this important regional conference as one of its objectives of broadening its activities and coverage at regional level so as to contribute to the economic advancement of regional state through enhancing economic policy formulation capability; the dissemination of economic research findings; promotion of dialogue on critical socio-economic issues; promotion of education in economics in higher learning institutions; and enhancing national, continental and global networks of professionals and institutions.

The Annual Regional Conferences that the Association has organized in collaboration with its Mekelle Chapter has created important forums for presenting and discussing development issues that are highly relevant to the Regional Socio-economy. These forums have also provided incentives for researchers to conduct research and present their findings on regular basis. Indeed, the Annual Regional conferences were organized in an interdisciplinary fashion, thereby widening the interactive coverage involving both economists living here in the region and those living outside the region and non- economists who are working and experiences on the region. The Third Annual Regional Conference on Tigray Regional State Economic Development has contributed towards a deeper understanding of the regional economy and the complex challenges it faces. It attracted about 100 participants including the region parliament members, the higher officials and expertise from Regional Bureaus, Universities, NGOs, private sector representative and EEA members in the region. The participants of the conference expressed their satisfaction on the organization of the

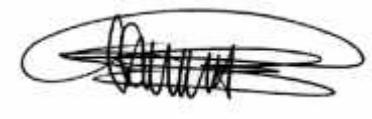
conference and the content of the papers presented. They reflected that the papers largely focused on local issue that can contribute to the development of the region. They also recommended that the issues raised in the discussion are critical that need due attention by policy makers and implementing organs of the region.

In this publication, all papers which were presented at the Third Annual Conference, and reviewed by external reviewers and comments and suggestions including editorial comments were communicated to authors for improvement. Finally, the papers which passed all the review and editorial process published in the Proceeding of the Third Annual Conference on the Tigray Regional State Economic Development.

I would like to take this opportunity to express my heartfelt gratitude, on my own behalf and on behalf of the Ethiopian Economic Association, to the many people and organizations that made the conference resounding success. First and foremost, I thank the authors of the papers and the audience whose active participations made the Conference meaningful. The staffs of the Economics Department of the Mekelle University which runs the EEA Mekelle Chapter, organizers and the staff of EEA Secretariat deserve a special recognition for their passion and perseverance in managing the conference from inception to completion. Mekelle University also deserves appreciation for hosting EEA Chapter by providing office.

Our special thanks go to our partners who have shared our vision and provided us with generous financial support to materialize the activities of EEA. These include; The Friedrich Ebert Stiftung of Germany, The African Capacity Building Foundation (ACBF), The Think Tank Initiative of International Development Research Center (IDRC) of Canada.

Finally, I would like to thank H.E. Ato Daniel Assefa Head of BoPaF of Tigray National Regional State for his continued support and an insightful opening remarks.



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Fertility Response to Parents' Resource Collection Intensity: Evidence from Southeast Tigray, Northern Ethiopia

Bahre Gebru[1]

Abstract

The neo-Malthusian argument that greater population adversely affects the natural ecosystem is well researched in the Ethiopian context. However, its counterpart vicious circle approach did not receive much attention so far. This research is generally aimed to explore the impact on households' fertility pattern of natural resource scarcity. Using data collected from 120 rural households in southeast Tigray, biprobit model was initially applied taking care of the simultaneity problem through the two stage conditional maximum likelihood (2SCML) estimation method. Results show that increasing the weekly parent's resource collection intensity by 10% is likely to promote the demand for an extra child by more than3%.

Keywords: fertility response; parent' resource collection; parents' collection intensity; children; 2SCML; Tigray.

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1. Introduction

Majority of the population in developing countries heavily rely on environmental resources (Rimjhim, 2006; Manyatsi and Hlophe, 2010). Such resources are important for the sake of drinking, animal feeding and as a source of heat. Like any other parts of the world, rural households in Ethiopia also rely on fast-degrading environmental resources including fuel wood, water and fodder (Zenebe et al., 2010). This is also well substantiated by Berhanu et al. (2002) who appreciated the importance of common property resources (CPRs) in rural Ethiopia as a means of grazing land, construction material and firewood.

Zenebe et al. (2010) reported that since urban households in Ethiopia rely on such rural areas for their firewood demand, environmental degradation gets worse-off with firewood scarcity. Berhanu et al. (2002) also indicated that woodlots management has escalated the everlasting shortage of firewood in the region. Shylendra (2002) examined the rehabilitation and livelihood impact of emerging trends from Tigray region (Ethiopia) and Gujarat (India). The findings, however, established that a fair treatment of participation equity and community benefit packages reflects the livelihood contribution of rehabilitated CPRs.

This area enclosure program in Tigray and the joint forest management program in India have improved livelihood of the communities at least through an increased provision of animal fodder. The author revealed that unlike its Indian counterpart, the area enclosure program in Tigray was more equitable due to the unreserved efforts of the "*Tabia*[2] bayto". However, both programs fail to address gender equity adequately. A similar study in India by Jodha (1990) in seven major states acknowledged the importance of CPRs for rural population in the high risk areas.

[2]*Tabia* is the lowest administrative unit in rural Ethiopia. It is synonymous with kebelle in Amharic.

The mismatch between population growth and natural resource base, however, becomes a head ache for many governments in Africa. Cleaver and Schreiber (1994) specially described Sub-Saharan Africa as a region with high population growth, fast environmental degradation, and sluggish growth in agriculture. Economists call the interdependence among these three issues as a 'vicious circle'.

The vicious circle of poverty indicates the action-reaction of forces that keep a country in a state of poverty (Ascher and Healy, 1990). Lutz and Scherbov (2000) further explained the vicious circle by a model whereby high fertility, environmental degradation and poverty patterns are combined with low human capital formation. They argued that the marginalized society suffer a lot from a pressurized environment in either of these sources.

It was argued that the process of natural resource degradation has exacerbated the drought-poverty-famine nexus in Tigray (Patricia and Smith, 2006). The Tigray Forestry Action Program (TFAP) report in 1996 portrayed that on average, fetching firewood requires 7-10 hours in the highland areas and 2-3 hours in the lowland areas of the region. This is probable from the situation that forests fail to meet the 4.33 million cubic meter approximate fuel wood requirement in the region. As a result, more than one-half and one-fourth million metric tons of dung and crop residues are burned for fuel purpose in the rural areas of the region, respectively.

Similarly, the Tigray Livestock Development Action Program (TLDAP) report in 1997 identified February, March and April as periods of critical feed shortage to feed livestock from crop residues. Due to erratic rainfall and climate variability, the regional level of crop production is below capacity resulting in inadequate amount of crop residues. TFAP (1996) reported that farmers in Tigray prefer to grow fodder trees in their farms to cope with the fodder deficiency. However, there is a problem due to over pressure of cutting and browsing by the livestock.

Households in Tigray region ease these problems by sending their children who have mostly comparative advantages in the acquisition of natural resources. In Enderta district, however, parents particularly fathers are involved in fetching natural resources mainly fodder and firewood. This is mostly evident in the collection of firewood where its source is far from residence. Evidences show that the population[3] of the regional state of Tigray has been increasing over time. It rises from 4.32 million in 2007 to about 4.4 million, 4.56 million, 4.68 million, 4.80 million, and 4.9 million for the years 2007-2012, respectively. The number of children[4], moreover, followed the same pattern. It reaches about 2.58 million in 2012 from 2.38 million in 2007 (Tigray Region Bureau of Plan and Economic Development). The possible assumption here is that parents may seek additional children (1) if they want to spend their time in other economic activities (other than resource fetching) with a better return and (2) for resource collection purposes when they are getting old thus incapable of gathering resources by themselves.

Children travel long distances and spend more labor time (Winkler-Dworak, 2003) in search of natural resources. The report from Tigray Region Bureau of Agriculture and Rural Development (2010/11) also indicated that Mekelle city received 1400 donkey load firewood in every Friday from the neighboring districts mainly from children of Enderta district.

The population-environment nexus, however, remained contestable among social and natural scientists. The usual point of debate is whether greater population worsens the natural ecosystem or a worsened environment necessitates fast population growth. While the impact of high population on the environment is relatively well documented (Hardin, 1968; Ehrlich, 1971), whether or not greater environmental degradation leads to an increased demand for children is mostly left uninvestigated particularly in the Ethiopian context.

[3] The population trend was projected using 2007 as a base.

[4] Children represents for those aging less than 19 years because of difficulty to separate in the data set.

There exists no universal measure of natural resources scarcity among social, natural and policy scientists. According to Mackellar and Vining (1989), an environmental resource is said to be economically scarce if the opportunity cost of obtaining it is high. The argument that the opportunity cost of time spent on resource collection adversely affects household's welfare is, therefore, used in this study.

The overall objective of this research is to explore the influence of environmental resources (firewood, water, and fodder) scarcity on the fertility patterns of rural households in south east Tigray, northern Ethiopia. More specifically, it is aimed to (1) investigate whether or not environmental resource scarcity increases the demand for children, and (2) scrutinize the effect of other socioeconomic factors on the fertility patterns of households.

The rest of the paper goes as follows: description of the study area, sources of data and model specification are detailed in section two. While section three shows the results and discussion part, the fourth section concludes.

2. Site description, data source, and empirical model

2.1 Site description

Tigray is one of the 11 regional states in Ethiopia. It is situated in the northern most tip of the country. It is bordered by Amhara region in the south, Afar region in the east, Sudan in the west and Eritrea in the north. The Central Statistical Agency (CSA, 2010) report shows that Tigray has a total population of 4,664,071 of which 49% are men. It has an area of 84,721.77 square kilometers and a population density of about 55 persons per square kilometer. Tigray has a cultivable land of about 1.2 million hectares. It has 46 districts and two development corridors - Humera and Maichew towns. About 83% of the population lives in the rural areas (Tigray Region Bureau of Agriculture and Rural Development, 2010/11).

The region has seven zones including the South east zone. This zone incorporates four districts: Saharti Samre, Degua Tembien, Enderta and Hintalo Wajerat. This study was carried out in South east Tigray covering Enderta and Hintalo Wajerat districts. It uses a cross-sectional data set of 120 rural households. Enderta and Hintalo Wajerat have a population of 123,537 and 164,554 with a population density per square kilometer of about 39 and 57 persons, respectively (CSA, 2010). These districts were purposively selected because their proximity to Mekelle (the regional capital) encourages collection and sale of natural resources especially firewood and fodder beyond their won consumption.

2.2 Data source

A detailed structured and close ended questionnaire was prepared and then translated into Tigrigna, the local language. Two enumerators were recruited and trained by the author on issues concerning neutrality and interviewing approaches. Familiarization exercise and response recording techniques were offered before leaving to the field. The questionnaire was pre-tested and data was collected between January and February 2011 on the basis of a multistage sampling procedure. Initially, two districts from the four districts in Southeast Tigray were purposefully chosen. At the second stage, '*Tabia*s' and villages were once again purposefully selected following the report obtained from the agriculture office of each district regarding the extent of involvement of households in collecting natural resources particularly firewood and fodder. The support of the development agents in each '*Tabia*' was indispensable in this regard. It is in this way that two '*Tabia*s' (5 villages) of Hintalo Wajerat district and three '*Tabia*s' (6 villages) of Enderta district are chosen for this research. All in all, the data was obtained from 120 households of which 78 households are from Enderta and the remaining is from Hintalo Wajerat district. A simple random sampling technique is employed to consecutively select households from each village.

The data set contained information on resource collection tasks by children and parents, socio-economic characteristics, income means, patterns of fertility, sources of environmental resources and time spent on other domestic tasks. This data was further substantiated with a focus group discussion conducted with firewood distributors in Quiha town and Mekelle city.

2.3 Empirical model

In developing economies where poverty is extremely severe, natural resources are important as a means of livelihood. Children have comparative advantage in fetching these resources. An important question here is what if the household does not have any child at all. One of the most fundamental decisions this household should make is whether or not to collect the environmental resources (firewood, water and fodder) by him/her self or intentionally bear children for this purpose.

The concepts of child and child labor lack common characterizations due to differences in setting the age restriction and the circumstances under which a child performs a specific type of work. For instance, the International Labor Organization (ILO, 2008:13) defines child labor as one that "encompasses work that is mentally, physically, socially or morally dangerous and harmful to children, and interferes with their schooling". For statistical measurement purposes, it also defines child labor as a group of individuals that fall in the age category of 5-17 years. However, as long as it does not negatively influence school enrolment and their health status, this ILO's report recognizes involvement of children aged 13 to 15 years on light work.

Likewise, article 2 of the ILO's minimum age convention No.138 sets the minimum age below which children should not be admitted to work at 15 (ILO, 1973). Depending on the age of the child and type of work performed, the United Nations International Children's Emergency Fund (UNICEF, 2004) also defined child labor as work beyond the minimum number of hours: a weekly economic work of at least 1 hour (for children aging 5-11 years), 14

hours (for those 12-14 years) and 43 hours (for children of 15-17 years). These were reflected in the ILO's convention on the worst forms of child labor, No. 182 (ILO, 1999). This convention treats all persons below the age of 18 as children. The maximum child age for this study is also restricted to 18 years following the ILO (1999's) convention that regards all persons less than 18 years as children.

Parents' decision to involve on environmental resource collection and/or other activities (by perceiving children as primary resource collectors) demands for modeling simultaneous equations. To this end, the bivariate probit model (Greene, 1998; Nankhuni and Findeis, 2004; Ndiritu and Nyangena, 2010; Gebru and Bezu, 2013) is adopted to trace resource collection participation by parents and fertility decisions.

The bivariate probit model comprises two binary dependent variables, Z_i where i=1, 2. The two dependent variables can represent either two interlinked decisions of the same agent or of various agents.

$$Z_{1i}^{*} = \beta_1^{'} X_{1i} + \varepsilon_{1i} \quad \textbf{(1)}$$

$$Z_{2i}^{*} = \beta_2^{'} X_{2i} + \varepsilon_{2i} \quad (2)$$

Where Z_{1i}^{*} and Z_{2i}^{*} are latent variables observed by the following conditions:

$Z_{1i} = 1$ if $Z_{1i}^{*} > 0, Z_{1i} = 0,$ Otherwise
$Z_{2i} = 1$ if $Z_{2i}^{*} > 0, Z_{2i} = 0,$ Otherwise

Z_{1i} shows whether each parent (the father, mother or both) is/are currently involved in resource collection on at least one of the resources in the past seven days before the survey. The value is 1 if the answer is yes and 0 otherwise. Z_{2i} refers whether this particular household did bear at least one child within the last five years. The value is 1 if the answer is yes and 0 otherwise.

The decisions by parents to collect resources by themselves and to have additional children for this purpose are modeled as a function of some explanatory variables (detailed in Appendix1). β_1' is the vector of coefficients of the explanatory variables. ε_{1i} and ε_{2i} shows the error terms in the collection and fertility models, respectively. They are assumed to be identically and independently distributed as standard bivariate normal with a correlation coefficient between the errors of ρ.

We first estimate the bivariate probit model following the presupposition that parental resource collection participation and the demand for more children are joint decisions. This happens if the ρ coefficient is statistically significant. Otherwise, the error terms will not be correlated (Greene, 1998) and hence, the univariate probit models are to be used.

That natural resource scarcity increases parent's time spend on collection, the likelihood of demanding an extra child by the i^{th} household may increase. Parent's resource collection intensity is, as a result, considered as an endogenous regressor in the fertility model.

$$Z_{2i} = \beta'_2 X_{2i} + \omega Z_{3i} + \varepsilon_{2i} \qquad (3)$$

Here, Z_{3i} shows the collection intensity of the i^{th} household introduced as a continuous variable in the fertility decision model and ω is its coefficient.
The two-stage conditional maximum likelihood (2SCML) correction procedure of Rivers and Vuong (1988) is preferred to other estimators if resource collection intensity is an endogenous predictor in the fertility equation. Greene (1998) argued that this procedure works well if at least one endogenous and continuous explanatory variable exists in the probit model. The computation of the 2SCML involves two steps: a reduced form Ordinary Least Square (OLS) regression is first carried out on parental collection intensity as a function of all exogenous covariates and the instrumental variable (IV) to generate the error terms. The saved error terms and the endogenous collection intensity variable are then

incorporated in the probit for fertility equation. If the standard t-statistics for the estimated coefficient of the error terms is statistically different from zero, collection intensity by parents will be endogenous in the fertility probit model (Wooldridge, 2002).

The structural form equation for the fertility model (equation 3) and the reduced form equation for the collection intensity model (equation 4) are estimated, where 'X' stands for the common exogenous variables in both equations, π is an IV in the collection intensity model with δ its coefficient.

$$Z_{3i} = \theta' X_{3i} + \delta\pi + \varepsilon_{3i} \qquad (4)$$

3. Results and discussion

3.1 Descriptive analysis

Results from the descriptive statistics reveal that about 80% of the sampled households are headed by males. Both parents (father and mother) live together in 75% of the households. The average age of household heads is calculated as 48 years and about 33% of them are literate – at least able to read and write. The mean family size is about 7. The age composition is worthy of mentioning in this regard. While each of the respondents, on average, has one child in the preschool age, they have about three children under the 18 years age range. More to the point, each household poses about one and two individuals in the age range of 19 to 24 years and 25 to 60 years, respectively.

The average monthly income of the households is 544 Birr[5]. Majority of this income (about 97%) emanates from other sources including income from agriculture, daily labor, food aid, remittance, and petty trading. The other 3% of income is obtained from selling natural resources including firewood, charcoal, and grass, among others. About 34% of the households are

[5] It is the official name for the Ethiopian currency. The official exchange rate was 1USD=13.56 Birr during data collection, January to February 2011.

located in Hintalo Wajerat district while the remaining is in Enderta. The respondents own an average of 6 livestock with the minimum and maximum of 0 and 10, respectively.

Table 1: Summary statistics of households' socio-economic characteristics

Household Characteristics	Mean	Standard deviation
Male headship	0.80	0.40
Parents living together	0.75	0.43
Head age	48.19	9.60
Literate household heads	0.33	0.47
Family size	6.71	2.38
Preschool (1-6 years)	0.87	0.78
Children (<=18 years)	2.88	1.49
19-24 years	0.67	0.78
25-60 years	1.75	0.57
Above 60 years	0.40	0.65
Monthly income (ETB)	544.15	238.96
Resource income	17	37.77
Other income	527.15	208.44
Household location (1=Hintalo Wajerat)	0.34	0.48
Livestock size	5.86	2.46

Environmental degradation complicates the problem of natural resource scarcity. Poor households who rely on the ecosystem for their daily livelihood are more likely to feel this worst impact. Such groups of people spend more time and effort in the pursuit of natural resources. Even though children tend to be the primary resource collectors in this regard, severity of the problem forces parents as well to collect resources by themselves. About 90% of the children and 95% of their parents are involved in collecting at least one of the resources.

This study considers 345 children who are below 18 years of age. Our findings indicate that all of the sample children spent about 8 hours on resource collection in a weekly basis. However, their parents spent about 25 hours for the same task in which fathers contribute about 71% of the

total time. While both children and fathers spend much of their time on fetching firewood and fodder resources, mothers focus on collecting water followed by that of firewood. The focus group discussion confirmed this that a group of firewood distributors in Mekelle city and Quiha town receive firewood from farmers mostly delivered by children. We can, therefore, conclude that children and fathers disregard collection of water as their common task. The same is true for mothers in the case of collecting fodder resource.

Table 2: Relative time allocated to resources in minutes by children and parents

Resource types	Weekly time (minutes) spent on resource collection by		
	Children	Fathers	Mothers
Firewood	236	726	48
Water	77	28	400
Fodder	160	307	5
Average	473	1061	453

Parents may lack time for other income generating activities when they also make themselves busy with other domestic tasks beyond resource fetching endeavors. Descriptive analysis shows that fathers spend one-half of the total time spend on other domestic activities by children. Parents as a whole spend about 59 hours on other domestic works. Herding of animals account for the largest share of hours spent for both children and that of fathers. However, mothers allocate much of their time towards cleaning and cooking followed by child care concerns as expected.

Table 3: Relative time allocated for other domestic works by children and parents

Types of work	Weekly time (hours) spent on other domestic tasks by		
	Children	Fathers	Mothers
Herding	11	11	0.87
Child care	6	0.62	12
Cleaning and cooking	11	3	33
Average	28	14	45

Our previous analysis highlighted that parents cover about 76% of the total household time allotted for resource collection. We also found that the average household age is about 48 years which is close to the life expectancy of an average Ethiopian. Moreover, much time spend on resource collection may prevent parent's involvement on other important economic activities. The question that we can pose here is, therefore, does an increased scarcity of environmental resources lead to a higher demand for children. Results show that majority of the surveyed households (about 83%) have experienced at least one child birth within the preceding five years. About 5%, 3%, and 1% of the households in the study area had reported a weekly resource collection intensity of about 0hours, 24hours, and 80hours, respectively.

3.2 Model diagnosis tests and the bivariate probit model estimation

We made an initial analysis of the data to take care of transformation of variable(s) for normality. While the other variables reveal a symmetric distribution in their level forms, the resource collection intensity by parents, collection intensity by children, livestock size and exogenous income of the household variables attained their normal distribution after transformation into natural logarithms.

The degree of correlation is also investigated between the regressors. The results assure that there exists no serious multicollinearity problem since the correlation coefficient in almost all of the variables is below 80% (Gujarati, 2004) in each model. The problem of hetroscedasticity is also checked in the parental resource work hours equation using the Breusch-Pagan or Cook-Weisberg test. The results show that there exists evidence for hetroskedastic model errors. The Huber-White sandwich technique is, therefore, used as a remedy. The specification test was conducted by using the Ramsey Regression Equation Specification Error Teston powers of the fitted values of 'Ln (parent intensity)' variable. The result indicates the presence of no omitted variables in the model.

Following the Hendry approach of model building – a general-to-specific, downward reduction to the final specification (Greene, 2003 and Verbeek, 2004), many variables that are assumed to affect household's fertility decisions and own resource fetching are initially incorporated in the preliminary estimation. Based on their coefficients, insignificant variables are consequently dropped from the bivariate probit model. This is carried out using the Wald and Likelihood-Ratio tests.

The rho coefficient between the equations' error terms in the bivariate probit model[6]is -0.26. The likelihood ratio test performed on the null hypothesis that the correlation coefficient (rho) is zero against the alternative that it is statistically different from zero provides a chi-squared statistics with one degree of freedom of 0.15 and a probability value of 27%. The null hypothesis cannot be rejected at any conventional level of significance and hence, we prefer the univariate probit models. The next section provides estimated results from the household collection intensity model and the 2SCML probit model for fertility decision.

3.3 What affects parent's resource collection intensity?

Results from the 2SCML are reported in Table 5. Models A and B show estimation results from the resource collection intensity equation and the probit model for fertility decision, respectively. The fertility model comprises the error terms from the parental collection intensity equation as a regressor to control and test for endogeneity of resource collection intensity.

An OLS econometric analysis made on model 1 indicates that about 34% of the variation in parent's resource collection intensity is explained by the explanatory variables included in the model. This shows the model fits well to the data. [Table 4].

[6] The author can submit these results upon request.

Table 4: Estimated results of parent's collection intensity and fertility decision models

Descriptions	Intensity model		Fertility model	
Variables	**Coefficient**	**P>|t|**	**Marginal Effects**	**P>|Z|**
Ln(parent intensity)			0.32***	0.01
Mother domestic hours	-0.56	0.38	0.72	0.82
Father domestic hours	-0.01*	0.09	0.21**	0.09
Preschool children	-0.07**	0.04	-0.39	0.49
Ln(income)	-0.32	0.15	-0.32	0.90
Ln (Livestock size)	0.32***	0.01	0.82**	0.03
Ln (children time)	-0.56**	0.04	-0.09***	0.00
Household location)(1=Hinta)Wajerat)	-0.02*	0.09	-0.02	0.10
Farm size	-0.79	0.20	0.06**	0.05
Head age	-0.33***	0.01	0.07**	0.06
Head age squared	-0.42**	0.06	-0.05**	0.03
Literate head	0.28	0.03	-0.11	0.07
Male headship	0.48**	0.04	-0.06	0.73
Fodder ratio	-0.12**	0.05		
Error terms			0.11	0.01
Summary statistics of the models				
No of observations	120		120	
R-Squared	0.34			
Log pseudo likelihood			-248.76	
Wald Chi-Squared			86.50	
Iterations completed			6	
Correct predictions			88.77	

Note: *, **, and *** means level of significances at 1%, 5%, and 10%, respectively.

The ratio of fodder expenditure to total exogenous monthly income included as an instrument for the endogenous 'ln (parent intensity)' variable is statistically significant at the 5% level. This is reflected in the first stage estimation (model 1) of the 2SCML procedure. Increasing the ratio of fodder expenditure to total income by one Birr reduces household's weekly resource collection burden by about 12%, keeping other things the same. This is true because purchasing fodder will reduce the time spending in search of this resource. The collection intensity reduces by 5 hours per

week among households who purchase fodder, keeping firewood and water constant.

The 'father domestic hours' variable in the collection intensity model conveys that, ceteris paribus, each additional hour allocated to other domestic chores by a father reduces his weekly collection time by 1%.This is as would be expected because rural households make labor and time reallocations among competing activities and leisure as well. Cooke (1998a) supported this argument. While this result resonates with the finding by Nankhuni and Findeis (2004) in Malawi, it contradicts with the finding by (2013) who reported that greater father resource hours increase resource intensity by children in Tigray.

When the number of preschool children in each household increases by one, holding other things constant, parents will spend about 7% less time per week on resource collection. This perhaps indicated that the presence of more children in the preschool age diverts parent's attention from collecting resources towards other domestic works probably to child caring. Nankhuni and Findeis (2004) also report that children's resource collection intensity falls significantly when the number of children in the 1 to 5 age range goes on increasing. Gebru and Bezu (2013), however, report an insignificant effect.

Ceteris paribus, parents will spend about 32% more time per week on resource collection if the size of livestock owned increases by 1%.This is not unusual because greater sizes of livestock demand much water and fodder resources holding the firewood demand constant. While this result contradicts with Heltberg et al.'s (2000) report in India, it matches with Gebremedhin et al's (2002) report which depicts the scarcity of feed resource in Tigray region. As a matter of fact, people keep their animals at home which demands much water and fodder.

If the resource collection intensity by all children in the household increase by 1%, parents will reduce their weekly collection time by about 56%, other

things held constant. The possible implication of this finding is that parents will get relief or engage in other productive economic activities with relatively better return if children are able to fetch resources intensively. This finding appreciates the relative importance of children in fetching natural resources. This may in turn promote the need to have more children among rural households.

The study also tries to look if there is any variation in collection intensity due to differences in location. The results show that parents living in Hintalo Wajerat district spend a 2% less weekly collection hours as compared to those living in Enderta district. This difference probably comes due to the fact that the former households are not as such involved in selling natural resources for the external market as compared to the latter ones. That is, the relative proximity of Enderta district to Mekelle city may further boost the effort to frequently supply firewood to the distributors.

The statistically significant negative coefficient of the 'age of household head' variable suggests that a one year increase in the age of the head reduces his/her expected weekly resource hours burden by about 33%, others held fixed. This is as expected since older household heads face difficulty of fetching resources from the remote areas. Rather, they demand children to do so. On the other hand, our results show that parental collection intensity per week falls non-linearly with age. This paper also scrutinizes the potential head-based work differentials and its consequent implication on resource work hours. Our results reveal that male headed households spend about 48% more time per week on resource gathering activities as compared to their counterparts.

3.4 Does parent's collection intensity promote the demand for children?

We used the percentage of correctly classified observations to determine the goodness-of-fit measure of a probit model. It shows the number of times the predicted and actual values of the dependent variable match. The

overall percent correctly predicted reflects a weighted average of the two (Cameron and Trivedi, 2009; Verbeek, 2004; Wooldridge, 2002). The fertility probit model, hence, correctly predicts "the household bears at least one child in the past 5 years" about 94% of the time and "did not bear any child" about 38% of the time. This model has generally correctly classified about 89% of the observations. The interpretations of these results are made using the marginal effect at the mean concept (Cameron and Trivedi, 2009).

The 1% level statistically significant coefficient of the error terms in the second model assures that parental collection intensity is endogenous in the fertility model. This vividly supports the use of an instrumental variable in the process of estimation.

The probability of bearing additional children increases by more than3% when the weekly parent resource collection hours rise by 10%. That is the likelihood of demanding more children increases with the scarcity of natural resources. Supporting evidence was obtained in Egypt by Levy (1985). The finding indicated that intensities in cotton industries in Egypt motivated farmers to have large families. The rest of the results are interpreted as follows.

When a father spends one more hour per week on other domestic activities other than resource fetching, this particular household is likely to demand more children by 21 percentage points. This indicates that parents seek supporters when they are busy with some activities. The result matches with Cooke (1998b) finding that more resource collection labor burden demands for greater women's collection time in Nepal.

An increase by one percent in the number of livestock increases the probability of bearing an extra child by 82 percentage points. Contrary to this, a 1% increase in the weekly resource collection intensity by children is likely to reduce the household's probability of having an additional child by 9%. This indicates that, keeping others constant, a household does not

purposively demand another child for resource fetching if these already born are intensively working on it.

Atsimdi increase in the size of farm land is likely to promote the demand for children by 6 percentage points. This was substantiated by Rosenzweig (1977's) finding that the demand for farm workers during the postwar years in the United States falls due to lower birth rates. Another important finding is related to the age of the household head. The coefficient of this variable in the probit model for fertility shows that the probability of demanding an extra child increases by 7 percentage points when the head's age rises by one year. The implication of this finding is that older parents always seek children who would be the bread winners of the family through involvement in income generating schemes when their parents are getting tired. The square of the head's age has also a non-linear but significant effect on fertility.

4. Conclusion

Environmental degradation forces rural households to spend more labor time and effort in search of natural resources including firewood, water, and fodder. Even though children are perceived as the primary resource fetchers, inaccessibility of these resources also provoked parents to involve in collection. This study is, therefore, aimed to explore the effect of parental collection intensity on the demand for children.

While all the sampled children spent an average of 8 hours per week on resource collection, their parents allocate about 25 hours per week. Fathers are observed to frequently and intensively involve in such tasks. The empirical findings also indicated that the extra demand for a child is possibly to increase by 3% when parents' weekly collection intensity increases by 10%. Higher father domestic weekly hours reduce the collection burden by parents but promote the fertility decisions positively. The size of livestock has also a positive effect on both collection intensity and the demand for children. More importantly, one additional resource

collection hour by children reduces their parent's collection intensity by 56 percent. This is likely to encourage parent fertility by 9 percentage points. The demand for children is likely to increase by about 6 percentage points as the size of farm by the household increases by one tsimdi.

This study, therefore, calls for a better natural resource management approach (area closure) and rural electrification; restriction on the number of livestock owned based on productivity matters, and promotion of rural saving so that households would be able to purchase natural resources at older ages instead of merely demanding children for this purpose. Such interventions reduce the resource collection intensity by parents and accordingly promote the utilization of family planning services thereby reducing the demand for children.

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Appendix 1. List and definition of variables used in the empirical model

No	Variables	Definition
Dependent Variables		
1	Model A: Ln(parentintensity)	Weekly resource collection hours by parents in natural logarithm
2	Model B: (Fertility decision)	The household bear at least one child in the past 5 years: 1 if yes, 0 otherwise
Explanatory variables		
3	Mother domestic hours	Weekly hours a mother spends on other domestic chores
4	Father domestic hours	Weekly hours a father spends on other domestic chores
5	Preschool children	Number of children below 7 years in a family
6	Ln (income)	Exogenous monthly income (excluding income from natural resources) in natural logarithm
7	Ln (livestock size)	Livestock value in tropical livestock units in natural logarithm
8	Ln (children time)	Weekly children resource hours in natural logarithm
9	Household location	The household lives in Hintalo district: 1 if yes, 0 otherwise
10	Literate head	Household head can at least read and write: 1 if yes, 0 otherwise
11	Farm size	Total area of land cultivated by the household in 'tsimdi'
12	Head age	Age of the household head in years
13	Head age squared	The square of household head's age in years
14	Male headship	The household is headed by male: 1 if yes, 0 otherwise
15	Fodder ratio	Ratio of fodder expenditure to household exogenous income in Birr

Household Decision Making Index Analysis and Determinants of Women Empowerment: Rural Tigray, Ethiopia

Menasbo Gebru[1] and Tefera Kebede[2]

Abstract

Women are key players in the agricultural sector of most developing countries. This study is aimed at examining participation of women in intra- household decision-making in farming activities and analyzing socio-economic factors that affect women empowerment. The study used multi-stage sampling techniques to select 153 rural women respondents. Descriptive statistics, Index analysis and Order logit model were used as analytical tools. Index analysis results showed 63 percent of married women respondents took part in decision-making on resource controlling, purchasing of expensive household materials. The order logit model result revealed that the presence of more adult males in a family affects women empowerment positively and age of women decreases women empowerment. The recommendation of the study includes that diversified source of rural income and better participation in formal education affect women empowerment positively.

Key words: Intra-household decision, women empowerment, Order logit model, rural Tigray

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1. Introduction

1.1 Background of the study

Women, are key players in the agricultural sector of most developing countries. However, despite their major role, men have continued to make farm decision-making, even in areas where women are the largest suppliers of farm labor. Previous efforts on women's role in agriculture concentrate only on examining their labor contributions. This assumption considers that women show little farm-level information to practice their role in decision-making, particularly in male subjugated cash and non-cash products **(Anselm and Taofeeq, 2010).**

Households are intermediate institutions between policies, programs and targeted individuals. An understanding of intra- household decision-making is essential for tracing effects of programs and evaluating policy impacts. Most studies evaluate policies at household level and overlook intra-household welfare maximization (Blumberg 1988; Blumberg and Coleman 1989; Due and Gladwin 1991; Gladwin and McMillan 1989; Kumar 1987). Using aggregate measures for instance, household income as a measure of welfare of a household will not be the best way to evaluate effects of development policy on intra-household level.

Unlike those in developed countries, women in developing countries are generally silent and their voices are stifled by economic and cultural factors. Institutional factors dictate gender-based division of labor, rights, responsibilities, opportunities, and access to and control over resources (Weiss *et al.*, 2000). Education, access to media, employment, and decision-making, among other things, are some areas of gender disparity practiced in developing countries (Morrisson & Jütting, 2005).Empirical evidence in Ethiopia shows that women do most of the work in the subsistent agricultural sector, while men are given the opportunities to engage in the commercial and causal sectors. Households often encourage male members to migrate to generate higher income through remittances (Chukwuezi, 1999).

The Tigray economy is predominantly agrarian and women are key players in agricultural activities. The Ethiopian constitution of Article 35/1995 and national policies are consistent with international legal instruments on gender equality, including the convention on elimination of all forms of discrimination against women (FDRE, 1995). Development strategies implemented in Ethiopia such as agriculture Development Led Industrialization (ADLI), Program of Accelerating for Sustainable Development to End Poverty (PASDEP), and Poverty Reduction Strategy Paper (PRSP) evidently have brought great improvement to welfare of rural households. However, have these strategies brought about measurable and tangible outcomes at individual level particularly rural women? The key aspect of this study is to examine the effectiveness of these developmental strategies in improving the lives of rural women through program's multiplier effect[2]. Many researches have been carried about gender equality and proxy determinants in Tigray but limited scope on household decision-making and women empowerment.

1. Most previous researches use binary logit model to analyse determinants of women empowerment. However, apart from sign effect, magnitude effect of proxy determinates has not addressed.
2. World Food Program (2013) examines women's empowerment using index analysis through incorporating border dimension of women participation while not addressing about proxy determinants. This study uses a new way of examining household level decision-making analysis, women empowerment and its determinants.

2 Programs implemented in rural infrastructure, irrigation, technology adoption, subsidies and direct transfer. All changes in welfare of households while implicitly woman is member of the household and by default, her life will improve provided that equal resource allocation among the household members.

1.2 Objective of the study

The general objective of the study focuses on examining household decision making index computation to examine the degree of women empowerment and its determinants in rural household of Tigray regional state. More specifically, the study has the following objectives:

1. To securitize the real decision maker at household level.
2. To estimate proxy determinants of women's empowerment at household level.

2. Literature Review

2.1 Family or individual decision-making

Literally, household decision-making and resource allocation are principal elements of economic and human development. Most of the time, intra-household decisions affect welfare of family members living within the household. According to Diego and Quentin (2010), decisions such as on choosing place of residing, means of income generating, pattern of investment, consumption and number of children constitute dilemmas encountered by households.

The concept of gender equality strongly correlates with concepts of social science mainly in the field of economics and sociology. It should be noted that due to technological dynamism and institutional change, opportunities for women bargaining power are enhanced over time (Agarwal,. 1997). According to a study conducted by Shoshana and Grossbard **(2010**) the unitary household model does not show women empowerment .The key feature of this argument is that decision-making at household level is to maximize common welfare of the household and no information is captured about women empowerment explicitly. Women are key players in the agricultural sector of most developing countries, but men (husbands) apparently and persistently dominate (Anselm and Taofeeq, 2010). This shows that women are not in a position to practice decision-making on farming activities commensurate with their contribution (IBID).

Socioeconomic factors provide significant explanation for the participation of women in farming activities. For instance, participation in formal education enhances women's decision-making in farming activities in Nigeria (Anselm and Taofeeq, 2010). Individual partner's command over financial resources manifests power exercise of household members. Furthermore, power balance of intra household is reliant upon relative access to resources, education and paid work outside home (Blood and Wolfe 1960). In most developing countries, due to male dominated culture, power of women in household and society is given a lower status (Balk, 1997). Despite their leading labor contribution about 60- 80% in agricultural activities in Nigeria, women's participation in decision-making is minimal (Yemisi et al, 2014).The male dominated culture makes women less articulate to express their problems and less efficient to solve their problems. Women always face limited access to credit, and credit associations discriminate among married and single woman (ibid). Likewise, low membership in cooperatives, less participation in extension services and low credit access affect Nigerian women negatively in controlling agricultural resource (Bila and Iheanacho, 2012).

In Ethiopia, rural women have limited practice in independent decision-making on most individual and family issues including choice to have children. From different perspectives, the tradition of Ethiopia is not encouraging regarding women empowerment. Right after the introduction of market oriented economic policy (1991), besides economic issues, social reforms especially gender equality took the attention of the government and undertook affirmative action for women. In all political, economic and social issues, gender has been mainstreamed as a pillar of country's development. However, improvements are not as expected especially in rural women.

The patriarchal style of life in the country encourages gender bias in household and community level decision-making processes (Bogalech et al, 2007).The socioeconomic challenges of rural women in Ethiopia make complex the empowerment component. According to Ogato *et. al* (2009),

the best way of practicing women empowerment will be through economic empowerment that liberates them from men's subordination. Furthermore, political, legal agricultural and productive resource empowerments are inevitable instruments of gender equality (see for detail **Ogato** et al, 2009). One study conducted in southern Gonder, Ethiopia, notes that due to low female controlling power of productive agricultural resources, female-headed households are more vulnerable to poverty than their counterpart male-headed households (Mosses, 2013).

Access to information maximizes opportunities and provides solutions to social, economic and political problems. Participation in extension services and information on role of the community influence the decision-making power of rural as well as urban women. The power to determine to have a child or not and implement family planning program is a crucial social issue in Ethiopia. Women with exposure to information on the role of the community, and health extension services have more power to decide having a child or not than those not exposed in Dire Dawa, eastern Ethiopia (Asres and Ranjan, 2014).

3. Data source and methodology

3.1 The Data

The study uses multi-stage sampling technique. Two local administrative units (*Weredas*), *Degau Temben* and *Enderta are* purposively selected. The selection criteria is based on closeness to the urban area to see that how location affects women empowerment. Six *tabias* (three *tabias* from *Dega Temben* and three *tabias* from *Enderta*) are selected randomly and finally residents from the list of *tabias;* 153 households participated in the study. The data include indicator of women's empowerment in four decision indices, namely, resource control index, decision on large household purchases index, Visiting family or relatives (mobility index), and participation index.

3.2 Method of Analysis

A. Index Analysis

Index analysis is perhaps the most direct measure of women's empowerment. It examines women's participation in at least four crucial decision-making processes. The index is framed in terms of women's participation (alone or jointly with their partners or someone else)in four major decisions (Anselm and Taofeeq, 2010). As far as the concept of women empowerment is concerned, it is the number of decisions a woman participates in a given household. A score value one refers to each decision making in a given household a woman participates and zero otherwise. The total score values gives the overall index. The index value ranges from zero (participates in none of the four decisions) to three (participates in all four decisions). Following the conceptual framework of index analysis applied in rural women empowerment analysis in Nigeria (Anselm and Taofeeq, 2010), we framed the estimation model for women participation index analysis in the rural Tigray:

$$RCI = \sum_{i=1}^{5} Xi \qquad \textbf{(1)}$$

Where

RCI = women participation in resources control (Resource Control Index)

Xi = features include in women decision making participation in resource control are five variables namely *buying routine HH*[3] *amenities controlled by husband*, *phrase expensive items*, *education and related expenses of children* , *using family saving*, *purchase or exchange of property.*

To determine for the second decision-making index (household purchase participation) as follow.

$$HPI = \sum_{i=1}^{3} Yi \qquad \textbf{(2)}$$

[3]Household

Where

HPI = Women participate in household items purchases decision (Household Purchase Index)

Yi = in women decision-making in household item purchase and are four variables. (*Spending personal income*, *borrow money, medical expenses of family).*

Similarly, to examine the mobility index of women in visiting relatives and performing other social and economic activities without prior notification to husband.

$$MI = \sum_{i=1}^{5} Zi \quad \textbf{(3)}$$

Where

MI = Mobility index (family visit).

Zi = items incorporating in women decision making participation in mobility for economic, social and biological purposes an incorporates five variables(i.e, *visiting women's' parental home, visiting market, visiting health institutions' attending religions occasion and visiting friends for enjoyment*).

Similarly, to address the activities participation of women in various social, economic and political activities, participation index formulated as fellow:

$$PI = \sum_{i=1}^{5} Qi \quad \textbf{(4)}$$

Where

PI= participation index

Qi = factors influence women participation in political and leadership and they are five.

Finally, aggregated individual index scores provide a measure of women empowerment within household over time.

$$WEI = \sum_{i=1}^{4} Ai = RCI + HPI + MI + PI \quad \textbf{(5)}$$

Where
WEI = women empowerment index
RCI = Resource control index
HPI = Household purchase index
MI = Mobility index
PI = Participation index
Ai = aggregate value of four indices women empowerment indicators. The higher index score, better women empowerment in household decision-making and the reverse is also true.

B. Estimation procedure

Considering the computation of empowerment index, the first step is ranking the index level from zero to three. That is to say that index with zero value refers a woman never participates in any of the four indices and index value with three typifies a woman participates in all four indices .An ordered logit model employs to estimate influence of household socio-economic factors on women participation in house hold decision-making. In other words, the dependent variable is ordinal categorical nature derived from index analysis through a Likert scale. This requires respondents to indicate the extent to which women participate in household decision making under three categories as: High = three, Medium = two, and Low = one.

The ordered logit model builds around latent regression in the same manner as the binomial probit model (Anselm and Taofeeq, 2010).

$$y* = \beta' X' + ui, \qquad \textbf{(6)}$$

Where y* is the underlying latent variable that indexes level of participation of women in a given household decision-making, X' is vector of variables expected to influence women's participation in decision making and U_i is stochastic error term with zero mean and constant variance. The latent variable exhibits itself in ordinal categories, codes as 0,

1, 2, and 3. The response of category i thus observes when the underlying continuous response falls in the i^{th} interval as:

$$yi = 0 \; if yi * \leq 0 , \quad \textbf{(7)}$$

Probability of women empowerment is zero

$$yi = 1 \quad if \; yi > 0 \; and \; y * \leq \partial 1 , \quad \textbf{(8)}$$

Probability of women empowerment is low

$$yi = 2 \; if \; yi > \partial 1 \; and \; y * \leq \partial 2 , \quad \textbf{(9)}$$

Probability of women empowerment is medium

$$yi = 3 \; if yi > \partial 2 \; and \quad y * \leq \partial 3 , \quad \textbf{(10)}$$

Probability of women empowerment is high.

Finally, censoring with ∂'s, unknown parameters ß will estimate in the structural equation (Greene, 2000).

The ordered logit model differs from univariate logit one is that the dependent variable (women empowerment index) is no longer binary variable rather an ordered variable with values low empowerment (1), medium empowerment (2), and high empowerment (3). As to a univariate logit model, the model supposes to build around latent regression equation. Lastly, it measures the probability of dependent variable (*Y*i, for i^{th} woman in given household) falls in one of the discrete categories conditional on levels of the independent variables (X_i).

$$y^* = \; _0 + \sum_{j=1}^{k} \; _j X_{ji} + u_i \quad \textbf{(11)}$$

Where x_{ji} is the aforementioned explanatory variables (See equation 6); u_i is the residuals or error term and β_0 and β_j are parameters (Greene, 2000). Bearing in mind equation (6), y_i^* is unobservable and one can only

observe whether the woman under consideration falls either in category "1," "2," or "3". Therefore, what is observed is the following actual placement in discrete category (i.e., low, medium and high decision-making participation).

$$y* = 1 \; if \; yi \leq \mu 2 \quad \textbf{(12)}$$

$$y* = 2 \; if \; \mu 1 \leq yi \leq \mu 3 \quad \textbf{(13)}$$

$$y* = 3 \; if \; yi > \mu 3 \quad \textbf{(14)}$$

4. Analysis and Discussion

4.1 Descriptive Statistics

4.1.1 Socioeconomic profiles of respondents

This part deals with a description of respondents' profile pertaining to economic, social, political and cultural issues. From the two *weredas* (*Degua Temben and Enderta*), a minimum of seven and a maximum twenty-five women respondents were selected and a total of 153 women respondents participated in the survey. Of these seventy-eight respondents from *Degua Temben wereda* and the remaining seventy- three from *Enderta wereda.*

From married women respondents, only 57(54%) were child breast-feeding and 48(46%) were not. Moreover, from divorced and widowed women, 26 and 15 percent are breast-feeding, respectively. This indicates that either marriage brake down or spouses passed away recently. Early marriage is a common practice in rural Tigray and this survey tried to address the extent of early marriage. Accordingly, 124(81.58%) of respondents married between 15-19 years of age and only 27(17.76%) married between 20 and 25 years of age. Under age, marriage is one concern of the region and the study verified that 98 percent of respondents married when they were less than 18 years old. From this finding, one can understand that awareness creation and proclamations introduced on the issue at region level about

women empowerment are not much effective. Of course, interviewed females might have married two or three decades ago when there was less or no concern about women's right and empowerment.

Table 4.1: Age vs corresponding first child delivery of respondents

Age (year)	Respondent size	% share	Com. %
15	12	7.8	7.8
16	20	13.1	20.9
17	11	7.2	28.1
18	31	20.3	48.4
19	24	15.7	64.1
20	17	11.1	75.2
21	13	8.5	83.7
22	11	7.2	90.9
>23	14	9.2	100.1
Total	**153**	**100**	

Source: survey, 2014

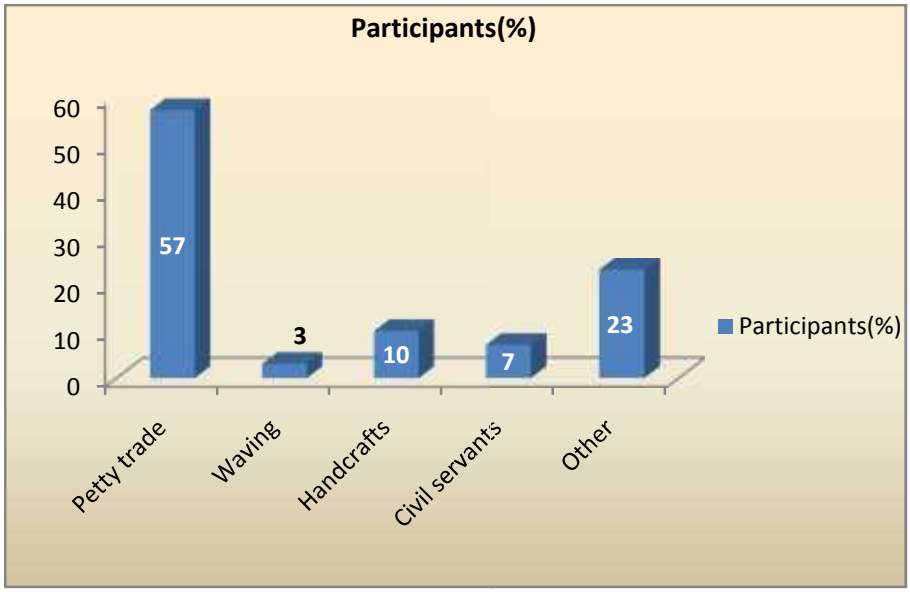
Marriage is social institution established between two consenting and interested individual of the opposite sex. However, in rural Tigray, woman marries by family decisions. *Enderta* and *Degua Temben wereda* are closer to Mekelle, capital of Tigray and we expect low chances of involuntary marriage due to urban life style spillover effect. Nevertheless, rural women marriage is still dominated by family decision. For instance, 34 and 31 percent of women respondents married for the first time without their consent in *Degua Temben* and *Enderta Wereda,* respectively. To sum up, 28.78 percent of all women respondents married without their consent.

4.1.2 Division of labor and rural women

Accommodating more family members in a given household leads to diminishing marginal returns on farm output, and an additional source of income will be needed. To investigate division of labor between men and women, women were asked about their job status and their perception of the future job demand. Only 30(19.6%) took part in off-farm income

sources and the remaining respondents invested their full-time on traditional farming activities. Figure 4.1 indicates types of jobs where rural women participate to cover household expenses.

Figure 4.1: Job type vs rural women participation



Source: Survey, 2014

Petty trading is considered an alternative income source of rural women next to farming activities. Waving takes the lowest share of off - farm rural women activity, as it is popularly handled by men. Being a civil servant for rural women accounts only for seven percent. Moreover, the survey tried to examine respondents' desire for off farm activities and the result depicts that 104(77.61%) were eager to have for new type of activities and 30(22.39%), were less interested in jobs other than farming. Of course, investment in human capital is a prerequisite for participating in non-farming activities and formal education will plays a great role in maximizing chances of joining the formal labor market. However the literacy status of rural women showed that almost all respondents were either illiterate or dropouts while they were at lower grade levels.

4.2 Gender Equality

Theoretically gender equality is a governing principle in Tigray. In practice, however, there are many cases, of gender inequality in the rural areas of the region.

Table 4.2: Perception of rural female towards gender equality

Social features	St. Disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	St. Agree (%)	Total (%)
Female are talented as of males	14	23	-	57	6	100
Marriage is prerequisite for happiness	7	17	1	63	12	100
Female and _male are equal at work	6	23	1	63	7	100
There are specific jobs for males only	21	27	4	46	1	100
Males should participate in home tasks	13	21	1	62	3	100
Female are subordinates of males	36	34	1	27	2	100
Democratic males respected by wives	33	12	1	49	5	100
More family size is prerequisite for happy life	21	25	-	45	9	100
Average	18	23	2	52	5	100

Source: survey, 2014

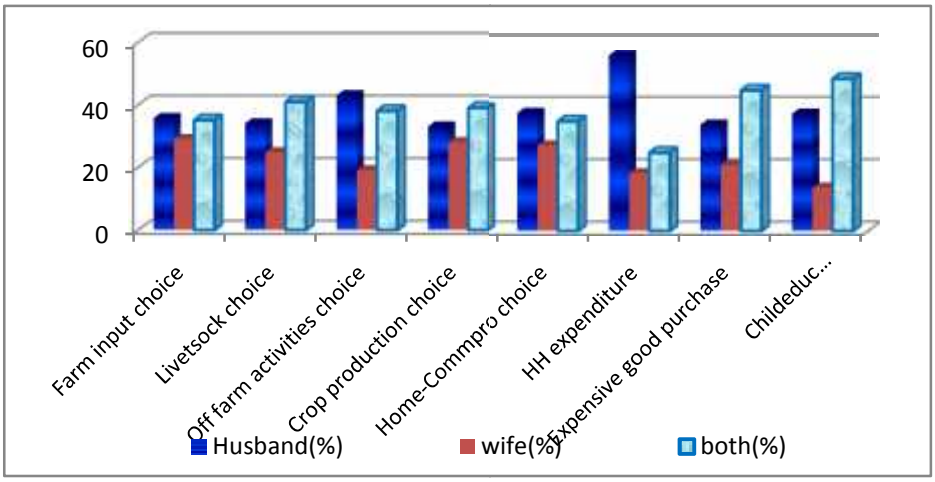
The five level Likert scale of rural women's perception and understanding of gender equality reveals that women agree with the principle of gender equity. Tigray's culture is patriarchal, as men become sole decision makers in households but the result contradicts this and subordination of women to men accounts only for 19 percent. Meanwhile, democratic men are respected by their wives, as they allow their wives to participate in household decision-making.

4.3 Rural women vs decision making in agricultural works

A large number of rural households consume agricultural products where all family members participate in farming activities. Nevertheless, choice of products for household consumption or commercialization differs from one

household to other. The aim of this study was to examine level of decision-making participation of women on the overall farming schemes. The following table reveals that in some of the decisions of a household women take a greater share and in some cases decision-makings is undertaken jointly. A few women are the ultimate decision makers if they head the household.

Figure 4.2: Decision making and rural women participation



Source: Survey, 2014

4.3 Household decision-making index analysis

The most common estimation method of women participation in household decision-making is index analysis. In this approach, responses are discrete and aggregate variables treated in such a way to generate index value of women participation. For effective estimation of the index, we employ order logit model and characterized the indices in line with practical involvement (participation) of rural women in household decision-making. The analysis considers four indices for estimation of women empowerment. Under each index, there are variables with values of 1, 2 and 3 A value of 1 refers in to political, economic and social activity, rural woman never participate a value of 2 for joint decision making and 3 indicates that rural women have full power to make any decisions. The following Table4.3 depicts the mean value of each index.

Table 4.3: Women empowerment index computation

Variable	Observation	Mean value	St.dev	Min	max
Resource control index	152	10.032	4.045	5	15
Household purchase index	136	8.683	2.737	4	12
Mobility index	150	9.073	3.887	5	15
Participation index	143	6.769	1.417	5	10
Average	145	8.63925	3.0215	4.75	13

Source; Survey, 2014

Table 4.3 presents level of women decision-making participation. The higher value of the indices, the better the involvement of women in decision-making, and the lower value, the least the involvement women in decision-making.

4.4 Determinants of women empowerment (Order Logit Model)

The Tigray economy is predominantly agrarian and women are key players in this business especially in rural communities. To estimate determinants of women empowerment, we employed ordered logit model and result is depicted in Table 4.4 below.

Table 4.4: Result of ordered logit regression model (probability of WE)

Explanatory variables	Coefficient	dy/dx (ME=low)	dy/dx (ME=Medium)	dy/dx (ME=high)	P>|z|
Headage(female)	-0.253	0.0083	0.054	-0.063	0.719
Marr-age	-0.1922	0.0063	0.041	-0.047	0.800
Famsize_male	0.673**	-0.022**	-0.145**	0.167**	0.023
Famsize_female	0.291	-0.009	-0.062	0.072	0.332
Member.assoc	0.614	-0.020	-0.132	0.152	0.605
Farm size	-0.168	0.005	0.036	-0.041	0.419
Female-age	-0.078*	0.002*	0.016*	-0.019*	0.096
Addchlsize	-0.0003	0.0000	0.000	-0.0195	0.998
Obs	**63**	**LR**	**chi2(8) = 8.97**	**Prob> chi2**	**0.3448**

** Significance at 5%, * significance at 10%

Source: Survey, 2014

Predicted value

Pr(P = 0), [the probability of women empowerment is low] = 0.034
Pr(P = 1), [the probability of women empowerment is medium] = 0.431
Pr(P = 2), [the probability of women empowerment is high] =0.534

The second column of Table 4.4 shows the sign effect of the explanatory variables on women empowerment. Coefficients with a negative sign refer to variables influencing women empowerment negatively and coefficients with a positive sign to variables correlated positively with women empowerment. Accordingly, female age correlates inversely with women empowerment while male family size positively with the women empowerment. Intuitively, the older the women, the less involvement they have in household decision-making process.

The third, fourth and fifth columns of Table 4.4indicate marginal effect of predictors on probability of women empowerment characterized as low, medium and high. For instance, presence of more men family members affect positively leading to high-level of women empowerment and presence less male members affect negatively leading to low and medium level of women empowerment. For an increase of one male family member in a given household, the probability of empowering women decreases for low-level by 2.2 percent, for medium level by 14.5 percent and increases for the high level by 16.75 percent at 5% level of significance *ceteris paribus*. This indicates that more male family members are concerned about empowering women. On the other hand, for an increase in the age of a female by one year the, probability of women low-level empowerment increases by 0.2 percent, the medium level increases by 1.69 percent and for the high-level empowerment decreases by 1.96 percent.

To sum up, predicted probability of women empowerment at different levels (low, medium and high) is consistent with the descriptive analysis where a greater percentage of women empowerment is found at the high level. Therefore, in the study area, the probability of women empowerment

at the lower, medium, and higher levels accounts for 3.4; 43.1 and 53.4 percent, respectively.

5. Conclusions and Recommendations

5.1 Conclusions

The study deals with women participation in intra-household decision-making. It focused on two *weredas* closer to Mekelle city. Female affirmative action and intervention using developmental packages at household level are effective in empowering women in decision making regarding social, economic and political participation but a lot remains to be done. Men participation in routine activities at home is another form of women empowerment and the study showed relatively good practice in this respect. Increasing adult men members in a given household affects women empowerment positively indicating that more men family members share the duty of women. Age of female significantly reduces their participation in household decision-making and their power of bargaining. The study explored the effect of women's off-farm activities on women empowerment and result showed that those having an additional source of income participated in decision making of resource allocation and household expenditure prior to notifying their partners. 5.2

5.2 Recommendations

This study showed that the participation of women in intra-household decision-making is good in the areas surveyed. However, a lot has to be done so that women can play their proper roles in social, economic and political participation. Based on the findings, the following recommendations are made.

1. Educated husbands give relatively more freedom to their partners especially regarding mobility and family visits. Hence, formal and informal adult education is important for women empowerment.
2. Diversified source of income enhances women empowerment and makes them less dependent on their partners. Hence, better expansion

of income generating programs in rural areas will make women less subordinate to men.

3. The study examined only two *weredas* and results are not conclusive. With more studies and sample size, better and robust results can be achieved. Thus, this study recommends comprehensive and detailed research in the future.

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Welfare Impacts of Urban Expansion in Peri-urban Tigray, Northern Ethiopia

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Abstract

Peri-urban villages, in many developing countries, are being incorporated to the respective urban administration to fulfill the growing demand of urban land. This has a direct effect on the production and consumption behaviour of farm households in the urban peripheries. This paper presents empirical evidence on welfare effects of the rapid urban expansion using a panel dataset from farm households in peri-urban Tigray, Northern Ethiopia, applying the difference-in-difference matching estimation method. The analysis shows that the farm households', incorporated to urban administration (treatment group) own smaller farmland and livestock compared to comparison group. The consumption expenditure of the treated households has significantly reduced compared to their counterparts between 2011 and 2012. This suggests that the targeted farm households would have been in a better condition had they continue to live under rural administration. This in turn signifies the gradual development of urban-induced poverty in the localities.

Keywords: difference-in-difference, farm households, matching, peri-urbanization, treatment effect, welfare

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[*]Data collection was funded by the Ministry of Agriculture and Rural Development of Ethiopia and Irish Aid for Ethiopia. I appreciated the generous institutional support of University College of Cork in Ireland, the Ethiopian Development Research Institute in Addis Ababa, Ethiopia and Mekelle University in Ethiopia throughout the research process. I thank Tassew Woldehanna, Catherine Porter and the anonymous reviewer for their invaluable comments and suggestions. I also thank the conference audiences at the Ethiopian Development Research Institute in 2013, the 19th annual conference of the African Region chapter of Econometric Society in 2014.

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1. Introduction

Urban areas of many developing countries, and particularly Africa, are expanding rapidly by incorporating the surrounding rural villages (Chen, Gu, & Wu, 2006; Gregory & Mattingly, 2009). This form of urban expansion eventually affects the production and consumption behaviours of farm households in the peri-urban areas. It is also important to note that the rapid urban expansion in sub-Saharan Africa (SSA) is structurally different from that of the East Asian or the developed countries. This is because food production has remained low (Jedwab, 2012) and the manufacturing and service sectors are small and inefficient (Vernon Henderson, Roberts, & Storeygard, 2013; Jedwab, 2012). It is also documented that urban areas of some SSA countries were expanding against the backdrop of economic growth (Fay & Opal, 2000; V. Henderson, 2003).

What causes the rapid urban expansion (or urbanization) in SSA is ambiguous and needs considerable debate. But at the early stages of development, economic growth and urbanization are accompanied by raising income inequality (Kuznets, 1955). This signals that the poor gain little from the early stages of economic growth or urbanization and becomes worse in cases where urbanization outpaces economic development. Similarly, Henderson (2002) points out that the rapid urbanization in developing countries leaves little space for the rural societies and institutions to acclimatize themselves to the urban ones. These issues have vital implications to farm households in the villages of peri-urban areas (PUAs).

In fact some studies indicate that the poor farm households likely become more vulnerable and marginalized as a result of urban expansion (Gregory & Mattingly, 2009; Mattingly, 2009). Additionally, moving out of poverty is more difficult for urban poor than rural poor (Bigsten & Shimeles, 2008). These issues in turn indicate that urban expansion induced poverty is likely to evolve in the peri-urban areas (PUA). Hence, it merits justifying empirically the effects of urban expansion in Africa at micro level to guide

policy for possible interventions. But the knowledge on the effects of urban expansion on welfare of the subsistence farm households' in peri-urban villages is, generally, very thin. Hence, this paper addresses the knowledge gaps partly by examining welfare of the farm households in PUAs using panel dataset from Tigray, Northern Ethiopia.

This paper has three main contributions. First, it aims to provide further evidence on the effect of peri-urbanization on welfare of farm households in the pre-existing rural villages. It mainly examines the effect of urban expansion on consumption expenditure and asset holdings of the farm households. Second, to the best of my knowledge, this study is the first to apply ex-post impact evaluation methods to examine the effect of urbanization on the peri-urban villages at a micro level using panel dataset in the context of SSA. Benefiting from nature of the data, we apply *difference-in-difference* matching estimator (Heckman et al., 1997) to evaluate welfare effects of urban expansion at micro level. The other is this study provides further evidence on peri-urbanization effects when land is owned by the state.

The challenge in evaluating the effect of policy intervention is establishing plausible counterfactuals. But interventions can be administrated either partly or fully to the population of interest where the later is the case in this paper. Following Abadie, Diamond, and Hainmueller (2010), inhabitants of rural sub-villages adjacent to the sub-villages incorporated to urban administration are considered for the control group. The motive to examine asset holdings of the farm households is to supplement the results of consumption expenditure data. The effect of urban expansion is, thus, investigated by applying difference-in-difference matching methods using panel dataset collected from farm households in peri-urban villages of Tigray, Northern Ethiopia.

2. Urban Expansion and Peri-urbanization in Ethiopia: an Overview

Ethiopia is among the poorest and least urbanized countries in sub-Saharan Africa. Since mid of 2000s, Ethiopia is achieving remarkable economic growth continually and urban population is growing rapidly as well. For instance, average annual urban population growth was about 4% in 2007 (Bane and Alemu, 2012) – twice of the growth rate of urban Africa (Montgomery, 2008). This growth rate is expected to continue for some time in the future because urban Ethiopia is still home to about one fifth of its people. To meet the growing demand of urban land use, urban areas redraw their boundaries by incorporating the nearby rural (sub-) villages.

Urban and rural areas of Ethiopia have defined administrative boundaries but urban boundaries can expand over time by policy. Demarcation of the revised urban boundary is enacted after the urban development plan is defended in a local public hearing and approved by the council (FDRE, 2008). As a result, the surrounding rural (sub-) villages incorporated to urban administration officially to implement the development plan. The urban administration incorporates the targeted rural (sub-) villages in consultation with the rural administration or the regional council. This ultimately creates a new boundary to the urban center and eventually shrinks land resources of the incorporated villages. From this, it can be argued that Ethiopia is adopting controlled urban expansion systems, at least by policy.

In Ethiopia, land is public owned and the land policy grants compensation to the dispossessed household (individual) when land is expropriated for investment purposes (FDRE, 2005). Based on the development plan, each urban administration allocates the land (farmlands and common lands) in its jurisdiction to different entities (i.e. individuals or private or public organizations). As a result, the dispossessed household's physical asset (land and sometimes housing) is replaced by financial asset (money) as compensation to the property loss. Land allocation is followed by

implementation of the different investments such as construction of new residential houses, public (private) institutions, manufacturing plants or installations of other urban amenities in very short periods of time. This is the stage where urbanization of the incorporated rural villages or peri-urbanization begins.

Peri-urbanization in Ethiopia, generally, follows a formal procedure where all inhabitants of the targeted villages are included into urban administration by law. In other words peri-urbanization, via land policy, affects the entire population of the targeted villages. This implies these villages are now governed by the urban development priorities which is a complete shift in their means of living. In cases like these, the dispossessed farm households likely face time and resource constraints to accustom themselves into urban livelihood systems and to benefit from the emerging employment opportunities. For instance, the survey data indicates that about 40% of the household heads still consider farming as their main job although have very limited access to farmland.

The rapid land use conversion– from subsistence agriculture to industrial, residential and other urban purposes – create heterogeneous social compositions and economic structures in the urban peripheries, particularly in the targeted villages. For instance, new residents mostly engaged in different sectors of the urban economy migrate to the locality; subsistence agrarian activities are progressively (mostly between two to five years) overtaken by trade, service and manufacturing activities; new land policies put in place and new land markets emerge resulting in commoditization of land and housing. Such type of transformations are observed in most peri-urban areas of Ethiopia, particularly in Tigray Regional State, and are quite similar to the peri-urbanization situations of many developing countries (Simon et al., 2004; Webster et al., 2004).

3. Data and Descriptive Statistics

3.1 Data

This study is based on a panel data collected in 2011 and 2012, same months, and right after the main harvest season from farm households in peri-urban Tigray, northern Ethiopia. The dataset consists of details of household demography, asset holding and consumption. Additionally, basic asset holdings of the households in 2006 were collected to account for pre-intervention covariates. The year 2006 is the earliest time where the targeted sub-villages in the sample being incorporated to urban administration. The total sample size in the first survey (2011) was 478 farm households and attrition rate in the second survey was 3%.

Four out of the tens big towns in Tigray Regional State, namely Mekelle, Adigrat, Axum and Alamata, were selected purposely considering population size, scale and size of the economic activities and natural resources endowments. Hence, these sites can represent urban expansion situation of Tigray Regional State. Proportional sample were drawn randomly from each survey site where each site has control and treatment groups. The treatment group consist farm households in the sub-villages (locally known *kushets*) but under urban administration, hereafter rur-urban households[3], who: i) gave up fully or partly their farmland between 2006 and 2009, ii) received land compensation, and iii) officially recognized as urban residents by the administration.

Sample for the control group was randomly drawn from inhabitants of sub-villages adjacent to the sub-villages of the treatment group but under the rural administration in 2010. It is important to keep in mind that part of the farmland for some the households could be under the urban administration due to the fragmented landholding systems. Peri-urban, in this paper, refers to the (sub-) villages within the radius of 15 kilometers from the edge of the urban built up.

[3] The word rur-urban created from two words – rural and urban – to represent the households' living style and the administration they belong to.

Farm household's livestock ownership is represented in constant prices[4] and tropical livestock unit (TLU) indices (details are given in Annex1). The monetary value of livestock is based on farm gate prices and adjusted for inflation using the producer price index (PPI)[5]. However, the TLU indices do not have a conversion factor for cross-breed or imported cattle such as bulls or dairy-cows. Hence, the index indicated for local cow is used to compute the corresponding TLU for cross breed or Holstein dairy-cow. As a result, the computed TLU is likely to understate the value of livestock for households who own cross-breeds or exotic breeds.

Per adult instead of per capita units are adopted for the analysis because the latter has the potential to overstate the consumption expenditures of a household with more children. Consumption expenditure consists of expenses on all food and nonfood consumable items except expenses on school and health – i.e. because school and health services usually available at subsidizes prices which becomes difficult to capture the cost reasonably. To construct household consumption expenditure, indices of Dercon and Krishnan (1998) are adopted (see details in Annex 2). The farm household's *ex-ante* asset holdings such as land, livestock and housing are adjusted for age and sex composition of the household and expressed in per adult units. But it is important to note that per adult units cannot fully capture the economies scale gained from the joint consumption of goods such as housing services and durable goods in the household.

3.2 Descriptive Statistics

Compared to control group (the rural households), heads farm households in the treatment group seem older and have fewer children (Table 1).

[4] Nominal livestock value is computed using the average local market prices for the respective items.

[5] All values are represented in ETB and corrected for inflation to the base year December 2010 using producer price index (PPI) available in the database of the Central Statistics Agency (CSA) of Ethiopia. The database is available at www.csa.gov.et .

Heads' literacy of the rural households is a little bit better than the rur-urban household heads. The proportion of female headed households has increased from 20% to 33% between 2006 and 2012 in rur-urban whereas in the rural it is stable around 26%. The rur-urban households' ownership of farmland and livestock has reduced and no significant change on housing between 2006 and 2012. Similarly, the rural households' livestock ownership has increased while size of farmland has decreased between 2011 and 2012. This could be possibly that some lost part of their land due to the fragment landholding system. But compared to rur-urban households, the rural households have larger farmland.

Table 1: Summary Statistics

Variables	Treatment group			Control group		
	2006 Mean (sd)	2011 Mean (sd)	2012 Mean (sd)	2006 Mean (sd)	2011 Mean (sd)	2012 Mean (sd)
Household Head age	50.61 (15.53)	54.67 (15.30)	55.25 (11.20)	43.53 (13.51)	48.11 (13.64)	49.24 (13.98)
Numbers of adults	2.94 (1.58)	3.11(1.72)	2.93 (1.67)	2.73 (1.32)	3.15 (1.53)	3.15 (1.53)
Number of children below 15 years old	2.15 (1.75)	1.73 (1.63)	1.73 (1.71)	2.33 (1.77)	2.29 (1.63)	2.32 (1.69)
Number of adults above 65 years old	0.24 (0.49)	0.01 (0.51)	0.33 (0.56)	0.07 (.27)	0.15 (0.39)	0.19 (0.36)
Livestock value in 000 ETB (in December, 2010 prices)		6.76 (11.5)	6.26 (9.62)		6.64(6.99)	8.14 (9.34)
Livestock in tropical livestock units (TLU)	3.86 (3.96)	2.63 (3.04)	2.62 (3.09)	3.13 (2.80)	3.14 (2.64)	3.15 (2.67)
Farmland owned in *tsimdi*	3.87 (2.36)	1.56 (1.55)	1.56 (1.55)	2.84 (2.19)	2.84 (1.03)	2.84 (2.02)
Number of rooms owned	2.38 (1.36)	2.90 (0.47)	2.60 (1.31)	1.88 (1.13)	2.00 (1.17)	2.05 (1.08)
Female headed household (%)	29.17	33.33	32.48	26.05	26.73	26.43
Household head farming main job (%)	62.08	46.25	36.59	68.90	70.16	61.94
Household head level of literacy						
Illiterate (%)	60	60.08	60.52	55.93	55.04	55.51
Adult literacy and church school (%)	7.91	9.16	6.03	9.75	10.08	7.49
Lower primary (grade 1- 4) (%)	10.42	12.08	11.16	17.8	17.23	17.62
Upper primary and above (grade 5 plus) (%)	18.74	16.67	22.32	16.51	17.65	19.38
Total sample (N)	240	240	234	238	238	227

Note: ETB is local known as Ethiopia Birr where 1USD was equivalent to 16.54ETB and 17.23 ETB on average during the first and second survey periods. *Tsimidi* is a local unit used to measure farmland and equivalent to a quarter of hectare

The proportion of the rur-urban household heads that consider farming as a main job generally has decreased between 2006 and 2012. The percentage of household heads in rur-urban that mainly depend on farming was about 63% in 2006 and decreased to 37% in 2012 while for the rural households it has decreased from about 71% to 62%. The decrease in the heads main job of rur-urban households concurs with the observed trends of livestock and farmland ownerships. Although access to farmland is limited, many rur-urban households still consider farming as the main means of living.

The distributions of pre-intervention covariates are provided in Table 2. It is observed that most covariates of the treatment and the control groups have similar distributions. This is a good indicator of having comparable groups. But factors such as age of the household head, number of aged members in the household and housing are significantly different. The households in the control group are significantly older, have more old aged members and more number of rooms per adult compared to their counterparts. Hence, these factors could be sources of bias and have to be controlled when evaluating effects of peri-urbanization.

In 2011, on average, real consumption expenditure of the rur-urban households was significantly higher than the rural households (Table 3). After a year, however, real consumption expenditure for the treatment group became slightly lower than that of the comparison group. Similarly, between 2011 and 2012, consumption expenditure of the treatment group decreased while increased for the control group. This seems that welfare of the rural households, as measured in consumption expenditure, has improved over a year while that of the rur-urban households' has reduced. This signals that welfare of the rur-urban households might be affected steadily by treatment (i.e. peri-urbanization) instead of the differences in other observables factors.

Table 2: Sample means and standard errors of pre-intervention covariates

Variable definition	Treatment Mean (Std)	Control Mean (Std)	Difference Mean (Std)
Household head age	50.59 (1.53)	43.53 (13.52)	-7.06 (1.33)***
Number of adults	3.02 (1.69)	2.84 (1.51)	-0.17 (0.15)
Number of children below 15 years old	2.15 (1.75)	2.33 (1.77)	0.18 (0.16)
Number of adults above 65 years old	0.24 (0.49)	0.07 (0.27)	-0.17 (0.04)***
Livestock in tropical units (TLU) per adult	0.80 (0.85)	0.77 (0.85)	-0.08 (0.07)
Farmland in *tsimdi* per adult	1.00 (0.98)	1.02 (1.07)	0.01 (0.09)
Number of rooms per adult	0.72 (0.81)	0.65 (0.70)	-0.32 (0.06)***
Female headed households (%)	0.30 (0.03)	0.26 (0.03)	-0.04 (0.04)
Household head farming main job (%)	0.62 (0.03)	0.69 (0.03)	0.07 (0.04)
Household head level of literacy:			
Illiterate (%)	0.60 (0.03)	0.55 (0.03)	0.05 (0.05)
Adult literacy and church school (%)	0.80 (0.02)	0.10 (0.02)	0.02 (0.03)
Completed grade 1-4 (%)	0.13 (0.02)	0.17 (0.02)	0.04 (0.03)
Completed grade 5 plus (%)	0.19 (0.03)	0.18 (0.02)	0.00 (0.04)
Sample size(N)	240	238	

Note: figures in the parentheses are standard deviations. *** represent significant at 1%.

Table 3: Mean and Standard error of consumption expenditure

Expenditure in 000 ETB	Treatment 2011 Mean	Treatment 2012 Mean	Treatment Difference	Control 2011 Mean	Control 2012 Mean	Control Difference
Real expenditure per adult	4.24(1.92)	3.93(1.77)	0.78***(0.16)	3.42(1.52)	4.07(2.06)	0.16(0.18)
Real food expenditure per adult	3.42(1.55)	3.15(1.38)	0.46***(0.13)	2.96(1.31)	3.42(1.77)	0.29(0.15)
Real non-food expenditure per adult	0.83(0.71)	0.78(0.61)	0.32***(0.05)	0.49(0.40)	0.66(0.56)	0.13**(0.06)
Sample size (N)	240	236		238	227	

Note: figures in parenthesis indicate standard deviations. *** and ** represent significant at 1% and at 5% respectively.

3. Estimation Framework

Peri-urbanization, via the land policy, affects the entire population of the targeted sub-villages. Like any other governmental or nongovernmental social programs, peri-urbanization could be regarded as a policy intervention targeted on the lives of the farm households in peri-urban areas. Empirical studies that focus on investigating the effect of social programs or interventions, generally, apply families of "average-treatment-effect" (ATE) methods (Wooldridge, 2002). To assess the effect of an intervention, it is required to know outcome of the treated household with and without the intervention. In cases where the *ex-ante* data is missing, the general practice is use control groups to generate the missing data and apply "matching methods".

As described previously peri-urbanization in Ethiopia, and particularly in Tigray, follows a formal procedure. This means inhabitants of the targeted peri-urban villages should comply with implementation of the urban development plan by law. Hence, a household in the targeted villages can hardly be outside the treatment. The control group for such kind of policy intervention should be drawn from villages in peri-urban area but not targeted by the policy. Such type of control groups are known as synthetic groups (Abadie et al., 2010) which means finding a comparable group that has similar characteristics to the entire population under the treatment but not affected by the treatment (policy intervention). Consequently, households in the control group were drawn from the peri-urban villages under rural administration and likely targets when urban expansion plan is considered again. This ensures that the two groups are drawn from similar socio-economic environments.

The average treatment effects of an intervention can be assessed using methods such as matching methods, regression model or selection model. But matching methods are complementary to regression; can identify the presence of sufficient overlap regarding covariate distribution and have diagnostics to assess their performance (Stuart, 2010). But matching

methods have no cure for perfect predictability of the matching index and for selecting the right conditioning covariates (Stuart, 2010). Being cautious of the pros and cons, matching methods is applied and formulation of the model for estimation is presented next.

4.1 Estimation Model

To formulate the effect of peri-urbanization (the treatment) on welfare the targeted farm household, i.e. outcome of the treatment: let Y_{it}^{R} be welfare of household i at time t in the absence of peri-urbanization, i.e. the counterfactual welfare for the treated. Similarly, let Y_{it}^{U} is the i^{th} household welfare at time t under the treatment. Consequently, the welfare gain (or loss) of the treated household as a result of the treatment is given as

$$G_{it} = Y_{it}^{U} - Y_{it}^{R}. \qquad (1)$$

However, it is impossible to observe both outcomes, Y_{it}^{R} and Y_{it}^{U}, for the i^{th} household concurrently. This means G_{it} cannot be constructed because of missing data problem (Wooldridge, 2002). But the counterfactual welfare (Y_{it}^{R}) can be generated from the control group under some restrictive conditions[1].

To account for participation in the treatment, a dummy variable D_i is generated where $D_i = 1$, if the household is treated and $D_i = 0$, otherwise. The sample units have two observations of the outcome variable. Let $t = 0$ and $t = 1$ represent observations before and after the treatment, respectively. The observed welfare for the treated farm household (farm household in the rur-urban village in this case) is defined as:

[1]The restrictive condition is known as ignorability of treatment which means conditional on the observables, x, the outcome (y_1, y_0) is independent of the treatment, w, (Rosenbaum and Rubin, 1983). This implies that $\mathrm{E}[y|w = 1, p(x)] - \mathrm{E}[y|w = 0, p(x)] = \mathrm{E}[y_1 - y_0|p(x)]$ which is the average treatment effect conditional on *pscore,* p(x).

$$Y_{it}^{U} = Y_{it}^{R} + G_{it}, \ (i = 1, \dots, n) \quad (2)$$

where Y_{it}^{U} is the observed welfare and Y_{it}^{R} is the counterfactual welfare (i.e. welfare of the farm household in rur-urban villages had the farm household been continued farming the farmland and lives under rural administration). Therefore, in hypothetical situations, the expected effect of peri-urbanization on welfare of randomly selected farm households in peri-urban areas, i.e. "*average treatment effect*", is specified as $E(G) = E(Y^{U} - Y^{R})$. Similarly, the average effect of peri-urbanization on welfare of the farm households in the rur-urban villages, i.e. the "*average treatment effect on the treated*", is given as:

$$E[(Y^{U} - Y^{R})|D = 1] \quad (3)$$

When the treatment is completely randomized, then *average treatment effect* and *average treatment effect on the treated* are identical. But most social experiments suffer from selection bias due to observed or unobserved factors.

Other than the treatment, welfare can be affected by confounding factors, (X), specific to the household. Hence, the average effect of peri-urbanization on welfare of the treated farm households conditional on observed covariates is defined as:

$$E[(Y^{U} - Y^{R})|X, D = 1] = E[Y^{U}|X, D = 1] - E[Y^{R}|X, D = 1] \quad (4)$$

The second term on the right hand side of equation (4) is expected welfare of the farm households in rur-urban villages had they not been include into urban administration, which is impossible to observe. The standard approach is matching with welfare of the control group by imposing the conditional independence assumption (CIA) (Heckman et al., 1998). Matching by controlling covariates might be difficult when the number of variables that influence the outcome is large. Hence, Rosenbaum and Rubin (1983) propensity score matching method is applied to overcome the curse

of dimensionality. This process produces predicted probabilities of all observables which in turn help to create comparable groups where entities with similar propensity scores are considered as matches (Heckman et al., 1998). Hence, the propensity score is generated by:

$$P(X_i) = Prob(D_i = 1|X_i) \quad (5)$$

where $P(X_i)$ is a propensity score (*pscore)*, which is the conditional probability of participation in the treatment, estimated using discrete choice model on pre-intervention household-specific factors, X_i, that satisfy the CIA condition (Caliendo and Kopeinig, 2008). To find a sufficiently close matches between the treated and control group, the common support condition ($0 < P(X_i) < 1$) is imposed to identify and consistently estimate the average treatment effect of peri-urbanization[2] (Wooldrige, 2002). Imposing the common support condition likely reduces number of observations in both groups. Let this sample be represented by θ which is a sub-sample of the total observations. Hence, the *average treatment effect on the treated* in the region of common support[3] is given as:

$$E[(Y^U - Y^R)|P(X), D = 1] = E[Y^U|P(X), D = 1, \theta] - E[Y^R|P(X), D = 0, \theta]. \quad \textbf{(6)}$$

Although matching eliminates bias due to observable differences, it is possible that household welfare to be affected by unobserved differences of the household such as preferences in consumption goods. Consequently, the model in equation (6) has to be modified to control such kind of unobserved bias.

[2] The matching procedure is all about finding the best possible match for the treated observations from the control group conditional on observed characteristics. The common support restriction helps to find the closest match for each rur-urban household from the rural households.

[3] Imposition of the region of common support criteria could likely throw away observations. Hence, observations outside the region of common support will be automatically excluded from the analysis.

Additionally, a set of criterion might have been applied by the respective urban administration to decide which way the town should expand or which rural village should be incorporated to the urban administration. Such decisions could possibly depend on the availability of social and economic infrastructures (such as market, road, school, health service and other facilities) in order to utilize the economies scale of the existing infrastructures. This indicates that administration of the peri-urbanization is not completely random although participation in the treatment is free of self-selection problems. These exogenous latent conditions of peri-urbanization decision are time-invariant and can be sources of unobserved selection bias. The difference-in-difference method (DD) is ideal to mitigate time-invariant selection bias (Heckman et al., 1998; Galasso and Ravallion, 2004; Ravallion and Chen, 2005).

The dataset of this study, however, have *ex-post* observations of the household's consumption expenditure (the outcome variable) and *pre* and *post* intervention observations on details of the household's demographic composition and basic asset holdings. As a result, the DD method cannot be applied due to missing data rather the model in equation (6) can be modified to estimate the outcome of interest. Accordingly, the effect of peri-urbanization on the targeted farm households' welfare over time in the region of common support is defined as:

$$E(\Delta G) = E\left[\left(Y_{i1}^{U} - Y_{i0}^{U}\right) - \left(\widehat{Y_{i1}^{R}}^{*} - \widehat{Y_{i0}^{R}}^{*}\right) | P(X_i), D_i = 1, i \in \theta\right] \qquad \textbf{(7)}$$

where Y_{i1}^{U} and Y_{i0}^{U} are observed welfare for the treated groups for two consecutive years, respectively; $\widehat{Y_{i1}^{R}}^{*}$ and $\widehat{Y_{i0}^{R}}^{*}$ represent estimated counterfactual welfare of the rur-urban farm households to be generated from the control group. Model (7) is similar to DD matching estimator (Heckman et al., 1997) and applied to control selection on observables and time constant unobserved factors. The other issue is that peri-urbanization possibly affects the control group activities at least in terms of new

employment opportunities, known as the *spillover effect*, but not captured in the estimation model due to data limitations.

5. Estimation Results and Discussion

5.1 Propensity Score

The pre-intervention covariates are used to estimate the propensity score (*pscore*). This ensures that the covariates are uncontaminated with the treatment or anticipation of the treatment (Dehejia and Wahba, 2002; Caliendo and Kopeinig, 2008). The pre-intervention covariates consist of factors associated with household welfare such as the household's demographic composition and asset holding and the local environment. The head is assumed to be influential in the consumption decision of the household. As a result, the household head's age, sex, main job and education status are considered. Family size is directly linked to consumption expenditure. To capture the effect of the household's production capacity on consumption expenditure, asset ownership (such as farmland, livestock and housing) and location of the household are included in the model. Presumably, keeping other factors constant, households with higher asset holdings likely have higher consumption expenditure and vice versa. Similarly, the household's production behavior is likely influenced by the local environment which is represented by the towns.

A *logit* model is regressed on the above discussed pre-intervention covariates. The parameter estimates of this regression are not interpreted because peri-urbanization affects all inhabitants in the targeted sub-villages where the household's decision to participate is not an issue. But this procedure is necessary to generate the *pscore* for matching and to create best matches between the treatment and the control groups, conditional on sharing similar pre-intervention covariates distributions. The estimation outputs of logit regression indicate that most variables are insignificant (Table 4). But few variables such as age of the household head and number of adults above 65 years old are strongly significant. Similarly, main job of the household head and number of adult in the household are weakly significant. The significant estimates indicate that the treatment and control

group are different with respect to the corresponding covariates. These results are similar to the summary statistics presented in Table 2. Hence, these covariates should be corrected before estimating the average treatment effect to avoid bias.

Table 4: Logit regression estimation results

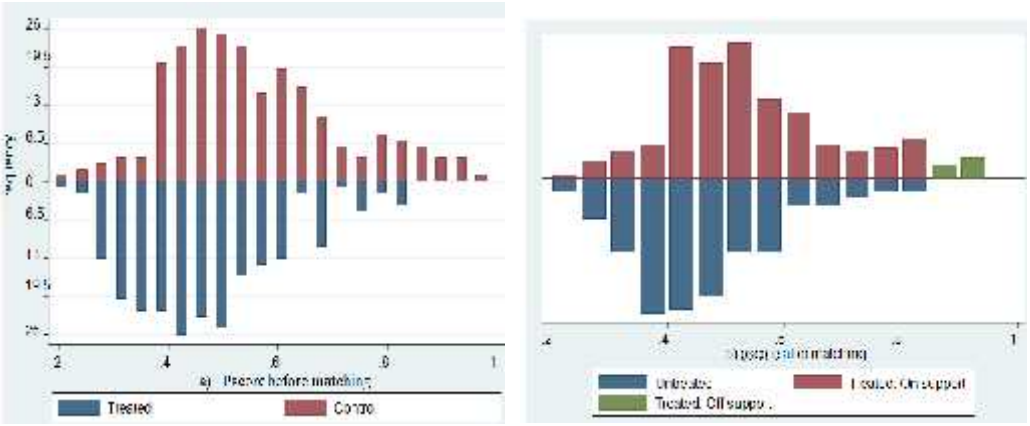
Variable	Coefficient	Std. Err.
Female headed households (yes=1)	0.34	0.25
Household head age	0.03***	0.01
Household head literate (yes=1)	0.25	0.22
Household head farming main job (yes=1)	-0.43*	0.24
Number of adults	0.12*	0.07
Number of children below 15 years old	0.04	0.06
Number of adults above 65 years old	0.89***	0.34
Farmland in *tsimdi* per adult	-0.19	0.13
Livestock in tropical units (TLU) per adult	-0.01	0.12
Number of rooms per adult	0.28	0.18
Location: base category Alamata		
Mekelle	0.02	0.31
Adigrat	-0.18	0.38
Axum	-0.08	0.38
Constant	-1.73***	0.58
Sample size (N)	454.00	
Psuedo-R^2	0.07	
LR χ^2	43.63	
Log-likelihood	-292.76	

Note: Due to missing values of some variables, the sample size used for the regression reduced to 454. ***, **, and * significant at 1%, 5% and 10% respectively.

Following the logistic regression, the common support condition was imposed to ensure that the treatment and control group are similar in their observed features. As a result, five optimal blocks with the same mean *pscores* are identified for both treated and control groups in each block. The region of common support is created in the range of [0.20, 0.95]. Additionally, the quality of overlap was checked using graphical diagnosis

pscores of the covariates distribution (see Figure 1). Panel (b) of Figure 1 indicates that *pscores* of both groups are substantially overlapped and few observations of the treatment groups are left unmatched. A caution is that *pscore* of the control group is distributed asymmetrically around *pscore* of the treatment group.

Figure 1: Distribution of propensity score (*pscore*) before and after matching



The purpose of estimating *pscore* is to select matches that closely resemble to the characteristics of farm households in the rur-urban villages from the control group. But *pscore* is a continuous variable which makes impossible to get exact matches (Becker and Ichino, 2002). The literature recommends different matching methods to overcome this problem. The most commonly applied methods include *nearest neighbor, kernel* and *stratification* matching. In general, one method is not preferred over the other. But when *pscores* of the control group distributed asymmetrically around the treatment group *local linear* matching – a version of the *kernel* matching – has an advantage over the others (Caliendo and Kopeinig, 2008).

As noted above, distribution of the relevant pre-intervention covariates was balanced on the basis of estimated *pscore.* However, conducting further test is recommended to ensure robustness of the estimation. The result of balancing tests of the covariates distribution before and after matching is provided in Table 5. The standardized median deviation of the *pscore* was

about 9.5% before matching for all the algorithms and become below 5%, the acceptable level of bias (Caliendo and Kopeing, 2008) after matching where the nearest neighbor matching algorism has the lowest bias. This indicates that the estimation results are robust to the different matching algorisms. After matching, the pseudo-R^2 decreased from 7.6% to 0.4% and p-values of the likelihood ratio tests become insignificant after the matching. These tests ensure that the proposed model reasonably identifies the *pscore* in terms of distribution of the covariates between the treatment and control groups.

Table 5: Matching quality indicators

Matching Algorithm	Pseudo-R^2 before	Pseudo-R^2 after	LR ¡ ^{2} (P-value) before	LR ¡ ^{2} (P-value) after	SMD before	SMD after
LLM[A]	0.0759	0.004	47.58 (0.001)	2.95 (0.58)	9.5	2.9
KM[B]	0.076	0.004	47.58 (0.001)	2.33 (1.00)	9.5	3.7
NNM[C]	0.076	0.004	47.58 (0.001)	2.46 (1.00)	9.5	2.3

Variables included in psmatch2 stata command are: hhsex98 hhage98 hhage2 hhedu98 hhjob98 hagb nadult98 nchildb1598 hhadt2 nadult6598 pfland98 ptlu98 proom98 Mekelle Adigrat Axum (definition of the variables is provided in Annex 3)
(A) represents local linear matching with band width 0.02, *biweght* weighting and common support.
(B) Represents kernel matching with band width 0.04, *biweight* weighing and common support.
(C) represents ten nearest neighbor matching with replacement, caliber 0.03 and common support.

5.2 Estimation of Average Treatment Effect

The single difference (i.e. equation 6) and the double difference (i.e. equation 7) matching estimation outputs are presented in Table 6. In general, the matching methods have produced similar estimation outputs. But relatively the kernel matching method has the highest bias and the *nearest neighbor* matching estimation output has the lowest bias (Table 5). For this reason, the discussion focuses on the estimation outputs of *nearest neighbor* matching. Discussions of the single and the double difference estimation outputs of the average treatment effect on the treated (ATT) are presented separately.

Table 6: Impact of urbanization on rur-urban farm households' welfare

Year	Matching Algorithm	No. treatment	No. control	Real food expenditure per adult		Real non-food expenditure per adult		Real total expenditure per adult	
				ATT	Std. Err.	ATT	Std. Err.	ATT	Std. Err.
In 2011 (single Difference)	LLM[A]	221	221	552.34***	150.72	335.09***	59.55	887.43***	180.68
	KM[B]	220	221	427.29***	149.96	326.71***	58.45	754.00***	179.48
	NNM[C]	199	221	574.42***	154.55	358.06***	61.10	932.48***	185.92
In 2012 (single Difference)	LLM[A]	199	221	-198.39	170.76	141.31**	63.97	-57.07	205.90
	KM[B]	220	221	-294.54*	169.99	137.23**	63.32	-157.31	204.81
	NNM[C]	199	221	-253.85	170.43	119.23*	66.76	-134.62	206.90
Between 2011 – 2012 (Double Difference)	LLM[A]	199	221	-750.73***	190.71	-193.77***	71.66	-944.50***	215.53
	KM[B]	220	221	-721.83***	189.32	-189.48***	70.62	-911.31***	213.80
	NNM[C]	199	221	-828.26***	196.16	-238.83***	74.24	-1067.09***	221.99

Note: ***, **, * represent significance levels at 1%, 5% and 10% respectively. A, B and C have same notes as in Table 5

Single Difference

On average, the rur-urban farm households' welfare, as measured in terms of real consumption expenditure, was significantly higher than the rural households in 2011 (Table 6). The results show that the consumption expenditure of the farm households in the rur-urban is improved by about 900ETB due to peri-urbanization. The major effect is on food expenditure (about 60%) whereas about 40% is on expenditures for nonfood consumable items. In general, the results suggest that rur-urban farm households were in a better position in terms of consumption expenditure compared to the rural household in 2011. The caveat here is that this could be consumption bubble caused due to utilizing the land compensation for consumption purposes because most of the households received land compensation in 2009.

In 2012, however, the consumption expenditure has decreased and the estimation results are mixed. On average, food consumption expenditure of the rur-urban farm households seems not different from that of the rural households. The effect on expenditures of nonfood consumable items is weakly significant suggesting the rur-urban households' consume higher compared to the rural households'. But it should be noted that the rural households' expenditures on utility is underestimated due to free access to alternative sources (for instance energy for cooking) or lack of access (for instance telephone services, tap drinking water). Overall, the total consumption expenditure of both groups is not significantly different which indicates peri-urbanization has no effect on the rur-urban households' welfare. But looking between 2011 and 2012, the results suggest that the purchasing power of the rural households catches up with that of the rur-urban households. This in turn indicates that the rural households are capable to satisfy at least the existing level of consumption while maintaining or improving their asset base.

Double Difference

From the single period matching estimates, it is difficult to conclude what the effect of peri-urbanization is. However, the double difference matching estimation output shows that ATT is negative and strongly significant (Table 6). This indicates that, on average, the rur-urban farm households' consumption is significantly decreased compared to their rural counterparts. For instance, between 2011 and 2012, the rur-urban farm households' expenditure decreased by about 1000*ETB* per adult. Out of this, the share of food consumption expenditure consists of about 78%. This in turn means that the poorest cohort of farm households in the rur-urban villages are the worst affected.

In sum, the estimation results indicate that peri-urbanization negatively affects welfare of the rur-urban farm households. At least the following reasons might contribute for this scenario. The first reason could be because of change in the production behavior of the rur-urban farm households. As observed during the survey periods, most of the fields in the rur-urban villages were under farming activities in 2011. But in 2012, these fields became active construction sites for nonfarm purposes. Secondly, the high consumption expenditure in 2011 could be a reflection of spending of the land compensation money because land compensation was mostly given between 2007 and 2009 and the land compensation money may be run out in the mean time if the household is not engaged in productive employments. Thirdly, the farm households might be less motivated to save the liquid asset in financial institutions because the real value of saving is negative, i.e. that interest rate is about 5% while inflation rate was about 33% in 2011 (Geiger and Goh, 2012). The other reason could be the high inflation rate might severely affect consumers rather than producers. This is because food consumption expenditure consists about 80% of the total expenditure and most of the rur-urban households purchase the major food items.

6. Conclusions

This paper has presented the effect of urban expansion on welfare of the targeted (rur-urban) farm households in peri-urban areas. Using panel data collected in 2011 and 2012 from farm household in peri-urban Tigray, Northern Ethiopia, we analyzed the changes in the farm households' welfare (as measured in consumption expenditure per adult equivalent) and physical asset holding. The difference-in-difference with propensity score matching approaches is applied to estimate the change in consumption expenditure. The analysis is, therefore, robust to selection on observables and unobserved fixed effects. Pre-intervention covariates of the farm households were controlled to estimate the average treatment effect on the treated (ATT).

The results have shown that urban expansion (or peri-urbanization) has diminished the physical asset, particularly livestock and farmland, ownership of the farm household in rur-urban villages but no changes in housing. This is not a surprising outcome because availability of farmland is reduced due to the nature of peri-urbanization. In subsistent farming systems, livestock and farmland ownership are positively associated because livestock usually serves support crop farming activities. But this likely suggests that the treated farm households are not engaged in the dairy sector. Consumption expenditure of the targeted (rur-urban) farm households exhibit mixed results but with a shrinking trend over time. In 2011, on average, consumption expenditure of the rur-urban farm households was significantly higher compared to their rural counterparts. In 2012 no significant difference was observed between the two groups. However, the change in consumption expenditure, between 2011 and 2012, is significantly lower for the rur-urban households than their counterparts.

The higher consumption in 2011may reflect consumption bubble due to use of land compensation money for daily expenses which again indicates consumption based on asset-depletion. But the reduction in consumption expenditure, after a year, could be due to: the high inflation in 2011 which

easily erodes the consumers' purchasing power and ultimately the households might run out of money in the absence of employment; and the change in production behaviour and/or lack of resources to finance their expenses. Hence, it can be generalized that the rur-urban farm households' consumption expenditure and asset base has diminished over time suggesting that the rur-urban farm households would have been in a better condition had they been continued farming with the privileges that their counterparts have. This in turn signals the gradual development of urban-induced poverty in the localities and also indicates providing only money as land compensation is not enough by itself. Hence, it is imperative to review the existing land compensation packages and design targeted interventions to improve the productive capacity of the dispossessed farm households and to promote sustainable urban development.

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Annex 1: Tropical Livestock Unit Indexes

Animal type	TLU index
Camel	0.1
Cattle	0.7
Sheep and goat	0.1
Horse	0.8
Mule	0.7
Donkey	0.5
pig	0.2
Chicken	0.01

Source: Adopted from Jahnke (1982)

Annex 2: Adult Equivalent Scales

Years of age	Men	Women
0-1	0.33	0.33
1-2	0.46	0.46
2-3	0.54	0.54
3-5	0.62	0.62
5-7	0.74	0.70
7-10	0.84	0.72
10-12	0.88	0.78
12-14	0.96	0.84
14-16	1.06	0.86
16-18	1.14	0.86
18-10	1.04	0.80
30-60	1.00	0.82
60 plus	0.84	0.74

Sources: Adopted from Dercon and Krishnan (1998)

Annex 3: Covariates included in the balancing test

Variable name	Definition
hhsex98	Household head sex in 2006; dummy female=1, otherwise=0
hhjob98	Household head main job in 2006; dummy farming=1, otherwise=0
hhage98	Household head age in 2006
hhage2	hhage98 squared
hagb	an interaction term for hhjob98 and hhage98
nadult98	Number of adults in the household in 2006
nchildb1598	Number of children below age 15 in the household in 2006
nadult6598	Number of adults age 65 plus in the household in 2006
hhadt2	nadult6598 squared
pfland98	Household farmland ownership in tsimdi in 2006 per adult
ptlu98	Household livestock ownership in TLU in 2006 per adult
proom98	Number of rooms owned by the household in 2006 per adult
Mekelle	Dummy for Mekelle town peri-urban, Mekelle=1, otherwise=0
Adigrat	Dummy for Adigrat town peri-urban, Adigrat=1, otherwise=0
Axum	Dummy for Axum town peri-urban, Axum=1, otherwise=0
Alamata	Dummy for Alamata town peri-urban, Alamata=1, otherwise=0

Economic Impact of Productive Safety Net Program on Poverty: Evidence from Household Survey

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Abstract

This paper aims at evaluating the impact of productive safety net program on poverty using primary data from randomly selected 600 households in 2010. Propensity Score Matching and Foster-Greer-Thorbecke were used to evaluate impact of the program and poverty, respectively. This study revealed that the program has positive and significant effect on consumption, livestock holdings, and productive assets. Moreover, impact of the program on total consumption expenditure per adult equivalent was found to be positive and significant. Using total poverty line, poverty rate was lowest among program participants (30.33%) than the non-participants (31.1%). The highest poverty rate was found among households headed by women (38.42%) while households headed by men (23.1%). The study also revealed that the program has positive and significant effect on poverty reduction and in protecting productive assets. Finally, it was recommended that female headed based programs should be provided to help boost their agricultural output and reduce poverty.

JEL: O12, O30, and R11

Keywords: Asset, consumption per adult equivalent, productive safety net program, propensity score matching, poverty, Tigray

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1. Introduction

Recently, the global focus has been to given food security and poverty alleviation. This is being made in response to the increasing food insecurity and poverty in the world. The incidence of food insecurity and poverty is devastating particularly in the developing countries and in terms of food insecurity; 852 million people worldwide are still chronically underfed. In Africa, an estimated 200 million (27.4 percent) people are famished (Babatunde *et al*., 2007). Eradicating extreme poverty and hunger is the first MDGs set by UN; this goal also has become the core development objective and agenda of the government of Ethiopia. The Plan for Accelerated and Sustained Development to End Poverty is Ethiopia's "guiding strategic framework". The key goal of PASDEP is to enable chronically food insecure households to acquire sufficient assets and generate income to move out of food insecurity and improve their resilience to shocks. Similarly, the main focus of the government's agricultural development strategy is to ensure self-sufficiency in food production at household level (ERSFE, 2009). Drought, environmental degradation, population pressure, limited access to services, shortage of farmland, lack of productive assets, low input and subsistence agricultural practices are the most prominent causes of food insecurity problems in rural areas of Ethiopia. Consequently, more than 38 percent of the rural households fall below the food poverty line and 15 percent of the rural population in Ethiopia reported that they experience a food gap of more than four months (MoARD, 2009). Realizing the magnitude and severity of the food insecurity, and linked to the PASDEP, the Ethiopian government and donors launched a Productive Safety Net Program (PSNP) in 2005 to shift millions of chronically food-insecure rural people from recurrent emergency food aid to a more secure and predictable, and largely cash-based, form of social protection. This program is the largest social protection scheme in Africa outside of South Africa's social grants schemes. The PSNP delivers social transfers to chronically food insecure rural households, either through public work activities or as a direct support with three distinct objectives of smoothing food

consumption, protecting household assets and building community assets (Devereux and Guenther, 2009).

However, some studies conducted in Ethiopia were at early stage of the program (Gilligan *et al*, 2008). Moreover, some of these studies used qualitative analysis (Barnes, 2008 Devereux *et al*, 2006; & Rachel *et al*, 2006). A survey regarding the impact of PSNP on poverty has not been yet evaluated, and remains untouched in the study areas. The Propensity Score Matching (PSM) and Foster-Greer-Thorbecke (FGT) were used to evaluate impact of the program and poverty, respectively.

2. Objective of the Study

The overall objective of this study was to evaluate the impact of Productive Safety Net Program on poverty. More specifically:

To examine the impact of Productive Safety Net Program on consumption
To examine the differentiated effect of the program on men and women
To assess the magnitude of depth, gap and severity of poverty differentials between program participants and non- participants

3. Methodology

3.1 Data and Procedure

To address the stated objectives, mainly primary data collected in 2010 was used. The primary data collection methods employed included both the use of structured and semi-structured type, focus group discussions and field observations to get information in-depth. Secondary data was also used to supplement the primary data from various outlets. A three-stage sampling procedure was implemented. In the first stage, the study area (Tigray) was purposely selected based on PSNP coverage. In the second stage, five weredas (districts) were selected randomly and finally, samples of 600 representative households were drawn based on proportional probability to sample size. Accordingly, 365 (60.8 percent) program participants and 235

(39.3 percent) non-participants were selected randomly using a systematic random sampling procedure.

3.2 Method of data analysis

The collected data were subjected to both descriptive statistics and econometrics analysis such as Foster, Greer and Thorbecke (FGT) index and Propensity Score Matching (PSM) to measure poverty and impact of the Productive Safety Net Program (PSNP), respectively.

3.3 Impact analysis

Choosing an appropriate model and analytical technique depends on the type of variable under consideration (Gebrehiwot, 2008). Here, the dependent variable of interest (program participation) is binary that takes a value of 1 and 0. Assessing the impact of any intervention requires making an inference about the outcomes that would have been observed for program participants had they not have participated. The appropriate evaluation of the impact of the program requires identifying the average treatment effect on the treated (ATT) defined as the difference in the outcome variables between the treated households and their counterfactual. Counterfactual refers to what would have happened to the outcome of program participants had they not have participated (Rosenbaum and Rubin, 1983; Becker, S., and Ichino, A. 2002 and Gilligan *et al.*, 2008). According to Rosenbaum and Rubin (1983), let Y^{PSNP} be the outcome of the PSNP participants and $Y^{non-PSNP}$ outcome of the non-participants. For each household, only Y^{PSNP} or $Y^{non-PSNP}$ is observed, which leads to a missing data problem. In estimating the propensity score, the dependent variable used was participation in the PSNP and Let Di denotes the participation indicator equalling 1 with probability of π if the household is program participant and 0 with probability of 1-π otherwise. Let X_i denotes a vector of observed individual

characteristics used as conditioning variables. Propensity Score Matching (PSM) technique was used which looks like as follow:

$$ATT_{PSM} = E_{P(X)}\{E(Y^{PSNP} \mid D = 1, P(X)) - E(Y^{non-PSNP} \mid D = 1, P(X))\}$$

The perception is that two individual households with the same probability of participation will show up in the participants and non-participants samples in equal proportions on the basis of propensity scores.

The following independent variables were selected based the PSNP guideline and review literature to estimate the propensity score. These are sex of the participants (dummy), age, land size, family size, access to credit (dummy), livestock holding, education status (dummy), access to irrigation (dummy) and shocks (dummy) (in the previous year) (see appendix 1).

3.4 Poverty analysis

The poverty situation of the program participants and non-participants was analyzed using the expenditure approach, the one developed by Foster, Greer, and Thorbecke (1984) known as FGT Index which is commonly applied for poverty analysis. A separate food and total poverty lines were developed for the study area using the Cost of Basic-Need approach (CBN) as proposed by Revallion and Bidani (1994). The three measures of poverty in the FGT index were employed of which the Head Count Index (P_0) which depicts number of population who are poor, Poverty Gap Index (P_1) which measures the extent to which individuals fall below the poverty line (the poverty gaps) as a proportion of the poverty line and Poverty Severity Index (P_2) that demonstrates not only the poverty gap but also the inequality among the poor (WBI, 2005). Let Z is the poverty line, Y_i is the actual expenditure (per adult equivalent) of individuals below the poverty line, n is number of people, q is the number of poor people normally those below the poverty threshold, α is poverty aversion parameter and is a value given (0, 1, or 2) to determine the degree to which the measure is sensitive to the

degree of deprivation for theses below the poverty line and higher values of α shows greater weight is placed on the poorest section of the society.
Then, the FGT or Pα is given by:

$$P_{\sim}(Z, Y) = \frac{1}{n}\sum_{i=1}^{q}\left[\frac{Z - Y_i}{Z}\right]^{\sim}$$

Therefore, if the value of α =0, the FGT or the Pα becomes the Head Count Index (P_0), when α = 1, Pα is the Poverty Gap Index (P_1) and α =2, Pα becomes the poverty severity index.

The Cost- of- Basic-Needs (CBN) approach was employed to estimate the poverty line for the 2010 collected data. Ravallion and Bidani (1994), and Dercon and Krishnan (1996, 2000) provided further information on the construction of the poverty line, including the details of the food basket and its sensitivity to different sources of data on prices used to value the food basket. Individual expenditures have historically been shown to be correlated with income level. The consumption expenditure approach was used to estimate the poverty line; accordingly, the food poverty line was 235 per month (2820 per year) per adult equivalent Ethiopian Birr. Once the food poverty line computed, the total poverty line was derived by taking the average food share of the first lower (first quartile) proportion of the population (WBI, 2005) which resulted in a total poverty line (TPL) of 330 per month (3960 per year) per adult equivalent Ethiopian Birr.

The most widely used poverty indices: the head count index (P_0), the aggregate poverty gap or poverty gap index (P_1) and poverty severity index (P_2) was employed. The head count index measures the share of the population whose consumption is below the poverty line (the share of the population that cannot afford to buy a basic basket of goods). The poverty gap index measures the extent of the poor (living below the poverty line) how far away from the poverty line and the poverty severity index

measures not only the gap but also the inequality among the poor (a higher weight is placed on those households further away from the poverty line).

4. Results and Discussion

4.1 Impact of the Productive Safety Net Program

The impact indicators used in this study were assets and consumption expenditure. Consumption is here measured as per adult equivalent, which is food consumption per-adult equivalent, non-food consumption and total consumption expenditure (food and non-food) per-adult equivalent.

The descriptive analysis of this study indicated that more 80 percent of the PSNP beneficiary households were not fully targeted in the program (all members of the PSNP beneficiary households of the program were not fully included in the program). This was of course due to quota targeting system, according to the response of PSNP beneficiary households'. This indicates that the PSNP beneficiary households would have improved their livelihood had they fully targeted in the program. Thus, the program had it implemented as it was intended in the program a lot of PSNP beneficiary households could have improved their livelihoods.

Family size: Out of the total sample respondents, 69 percent of them were male headed households and the remaining 31 percent female headed households whose livelihoods are based on farming activities. About 82 percent of the sample respondents were illiterate while 18 percent of them were literate. Male-headed households participated more relative to the female-headed households in the study area. Out of the total male-headed household respondents, 65 percent were from the PSNP participants. Only 35 percent of the female-headed households were PSNP participants out of the total female-headed sample. There was statistical significant (at 1 percent) mean percentage difference between male-headed and female-headed households in PSNP participation. This result was in line with the study done by Gilligan *et al*. (2008) whose findings on the PSNP indicated that participants in the public work were more likely to come from male-

headed households with married head. Family size and program participation have positive relationship. On average, program participants (6) have a bit larger family size than the non-participants (5). The combined average family size for sample respondents was six persons per household. The mean difference in family size between program participants and non-participants was statistically significant (at 5 percent). The result revealed that households with higher male adults were participating more in the program than those who have less male adults. Thus, the mean difference of male adults between program participants and non- participants was positive. Statistically, this was found to be significant at less than 1 percent level of significance.

Age of the household: The mean age of the sample household heads was found to be 49 years. The mean age of program participants and non-participants were 49 and 48 years, respectively. On average, the cultivated landholding size of the sample respondents was about 0.45 hectare.

Land holding size: The average cultivated landholding size for program participants was 0.35 hectare whereas that of the non- participants was 0.38 hectare. Thus, the mean difference of the landholding between program participants and non- participants was found to be not statistically significant.

Livestock holding: The average number of livestock owned by the sample respondents prior to the program intervention (productive safety net program) was converted into tropical livestock unit (TLU) and this was used as lagged variable in matching technique. On average, the sample respondents have had about 3.7 while the program participants and the non- participants have 3.5 and 3.3 TLU, respectively. Prior to the program intervention, however, the mean difference in terms of TLU between the program participants and non- participants was found to be not statistically significant. Currently, on average, program participants and non-participants have 4.5 and 2.5 TLU, respectively. The result revealed that on average the TLU of the program participants have increased from 3.5 to 4.5

while that of the non- participants have decreased from 3.3 to 2.5. After program intervention, the average size of TLU for program participants has increased by one fold while that of the non-participants has declined by 0.8. Statistically, this was found to be significant. Oxen are important assets and were treated separately; on average the sample respondents have about 1 TLU. The mean oxen TLU for the program participants and non- participants were 1.16 and 0.67, respectively.

5. Econometric Analysis of Welfare Effects (Impact of PSNP on Assets)

5.1 Impact on Livestock holdings

The average the TLU of the program participants has increased from 3.5 to 4.5 TLU while that of the non- participants have decreased 3.3 to 2.5 TLU. After the program intervention (productive safety net program), the average size of program participants has increased while that of the non-participants has declined. The mean difference in terms of TLU between program participants and non- participants was found to be positive and statistically, significant at 1 percent level of significance.

5.2 Impact on productive asset

All asset categories have been valued in Ethiopian Birr based on their current prices as reported by each sample respondents, but deflated. The result indicated that the value of the productive assets at their prices (but deflated) was higher for program participants than non- participants. The difference in the mean value of the productive assets between program participants and non- participants was positive and statistically significant (at 5 percent and at 10 percent using radius and kernel, respectively), but it was significant based on nearest neighbor matching estimators.

5.3 Impact on durable and household goods

The impact of the PSNP on the value of the durable goods was positive and statistically significant (at 10 percent). This indicated that the program participants were able to protect their durable goods as a result of the program's intervention. The mean value of the durable goods was found to be positive and statistically significant (at 5 percent). The impact of the PSNP on household goods was found to be positive and statistically significant (at 1 percent). A study conducted by Devereux *et al*. (2006) indicated that the impact of the program on assets protection has positive and significant effect (at 10 percent). In terms of asset protection, non-participants had more likely to experience decrease in their asset-holding than program participants.

Table 1: ATT Estimation Results of the Impact of Productive Safety Net Program on Assets

Outcome variables	Estimators	No. of PSNP participants	No. of non-PSNP participants	ATT	t-values
Livestock	Nearest Neighbor	332	123	1.966	3.490***
	Kernel	210	143	1.845	10.375***
	Radius	212	143	2.012	8.647***
Productive asset	Nearest Neighbor	218	123	31.397	1.031
	Kernel	218	143	35.609	1.661*
	Radius	218	143	38.324	2.357**
Durable goods	Nearest Neighbor	218	123	34.518	2.154**
	Kernel	218	143	36.075	2.329**
	Radius	218	143	33.882	2.059**
Household goods	Nearest Neighbor	218	123	89.321	3.627***
	Kernel	218	143	80.196	3.744***
	Radius	218	143	70.202	3.292***

Significant differences are indicated with: * p<0.05 (5 percent level), ** p<0.01(10 percent level), *** p<0.001 (1 percent level) and standard errors are bootstrapped.

5.4 Impact of Productive Safety Net Program on Consumption

Consumption expenditure was used as impact indicator while evaluating impact of the program (PSNP), and it was computed as per adult equivalent consumption expenditure.

5.5 Impact on consumption expenditure

The result of this study revealed that on average, program participants consumed more food items as compared to the non-participants. The difference in the mean value of food consumption per adult equivalent between program participants and the non- participants was found to be positive and statistically significant (at1 percent). Therefore, the overwhelming majority of program participants participating in the PSNP consumed more food items. A study conducted by Gilligan *et al.* (2008) found that positive impact on per capita food expenditure and this was statistically significant (at1 percent) for program participants.

Thus, program participants were more likely to consume more food as compared to the non-participants. The estimated non-food household consumption expenditure per adult equivalent was positive, but it was not statistically significant. The total (food and non-food) consumption expenditure per adult equivalent for program participants was found to be higher as compared to that of the non- participants. The estimated results indicated that the mean total consumption expenditure per adult equivalent for program participants was positive and statistically significant (at 1 percent). The principal results of the study on consumption expenditure showed that the program intervention (productive safety net program) enabled program participants to increase household consumption expenditure very considerably. A study conducted by Devereux *et al.* (2006) noted that 75 percent of program participants have been reported that they consumed more food of better quality and Barnes (2008) also noted that the PSNP had positive and statistically significant (at1 percent) impact on household consumption expenditure.

Table 2: ATT Estimation Results of Impact of PSNP on Household **Consumption**

Outcome variable	Matching method	No of PSNP participants	No of PSNP non-participants	ATT	t-values
Food consumption	Nearest Neighbor	332	123	1254.59	6.960***
	Kernel	218	143	1061.25	8.144***
	Radius	218	143	1070.22	9.227***
Non-food consumption	Nearest Neighbor	218	123	9.50	0.127
	Kernel	218	143	30.98	0.620
	Radius	218	143	31.04	1.011
Total consumption	Nearest Neighbor	218	123	305.75	3.753***
	Kernel	218	143	242.72	4.072***
	Radius	218	143	241.50	5.303***

Significant differences are indicated with: * p<0.05 (5 percent level), ** p<0.01(10 percent level), *** p<0.001 (1 percent level) and standard errors are bootstrapped.

6. Econometric analysis of poverty

6.1 Poverty Line (TL)

The incidence of poverty was analyzed using the total poverty line (330 per month or 3960 per year per adult equivalent Ethiopian Birr) and then food poverty line of 235 per month or 2820 Ethiopian Birr per year per adult equivalent. Accordingly, 30.33 percent of the respondents were living below the poverty line with poverty gap index of 6.6 percent and poverty severity index of 2.77 percent. Ahferom (30.33 %) and Merebleke (25.55%), with poverty gap and severity index level (2% and 0.55%) and (1.85% and 0.45%) were the leading woredas (Districts) in this zone with their high and low level of poverty, respectively.

Table 3: Incidence of Poverty by Woreda (Districts)

Woreda (District)	Poverty Estimates			Total Poverty line
	P_0	P_1	P_2	
Geter Adwa	0.351(0.038)	0.052(0.009)	0.013(0.003)	330
Ahferom	0.313(0.031)	0.054(0.008)	0.016(0.003)	330
Kola Temben	0.346(0.036)	0.049(0.008)	0.013(0.003)	330
Merebleke	0.320(0.036)	0.025(0.009)	0.007(0.003)	330
Lailay Maichew	0.308(0.042)	0.077(0.014)	0.029(0.008)	330
Population	0.328(0.008)	0.084(0.003)	0.031(0.001)	330

Values in brackets are standard deviations

6.2 Poverty and gender of the household

Most studies on poverty stated that the probability of female headed households to fall into poverty is much greater than male headed households due to less educated in the population, cultural values, and lack of physical and human capital (Fitsum T., 2002, Mok T. Y. *et al,* 2007). The probability that a household will be poor when headed by female was significant at 5 percent level of significance. Therefore, the probability of female-headed households was more vulnerable to the prevalence of poverty than those of male headed households. There was statistically significant difference on the level of poverty across gender at 5 percent level of significance. About 30 percent of the female headed households were found to be below the poverty line with poverty gap index of 7.3 percent and severity index rate of 2.6 percent. Only 23 percent of male headed households were found below the poverty line with poverty gap index of 0.062 and squared poverty gap index of 0.028. Thus, the incidence of poverty was higher for female headed households than male headed households (Table 4).

Table 4: Incidence of poverty by gender

Sex of the household head	Poverty Estimates			t-statistics
	P_0	P_1	P_2	
Female	0.301(0.0021)	0.073(0.0051)	0.026(0.0023)	
Male	0.231(0.0076)	0.062(0.0025)	0.028(0.0011)	0.004***
Population	0.233(0.0046)	0.061(0.0031)	0.026(0.0010)	

***Significant at 1% & values in parenthesis are standard deviation

6.3 Poverty and education

As most studies have indicated, education has positive and significant impact on poverty. Highest level of poverty of 35.55 percent (head count index) was observed in illiterate households; accompanied by high level of poverty gap index 9 percent and severity index of 1.65 percent.

6.4 Poverty and family size

Significant numbers of research works carried out to express the relationship between poverty and family size revealed that there is an inverse relationship between households' size and that of poverty status of the household. A household who have a larger family size has the higher probability of falling into poverty (Esubalew, 2006). The average family size of the sample respondents was 5.66 per household. Whereas the average family size of the program participants was 5.33 per household while that of the non-program participants was 4.85 per household.

As the family size of the household increased, the incidence of poverty also increased. About 6.3 percent of the households that had a family size of 2-3 were living below the poverty line with income short fall of 3 percent and poverty severity index of 1.1 percent. About 12.8 percent of the households with family size of 4-5 were living below the poverty line with poverty gap

index of 4.12 percent and poverty severity index of 1.88 percent. Thus, as has been indicated by most empirical literatures, the level of poverty had increased directly with an increment of family size of the households.

6.5 Poverty and Productive Safety Net Program

The program participants were 60.8 percent (n=365) while the remaining 39.3 percent (n=235) were non- participants, but eligible. The result revealed that the poverty level of the program participants was lower than that of the non-participants. The results also indicated that 30.33 percent of the program participants and 31.11 percent of the non-participants were found to be living below the total poverty line. Furthermore, the poverty severity index was lower for the program participants.

Table 5: Level of Poverty by program participation

Variable	Total Poverty Estimates			TPL	Food Poverty Estimates			FPL
	P_0	P_1	P_2		P_0	P_1	P_2	
Participants	0.3033	0.066	0.025	330	0.370	0.045	0.021	235
Non-Participants	0.3110	0.059	0.022	330	0.391	0.051	0.026	235
Population	0.30615	0.0624	0.025	330	0.383	0.053	0.020	235
Pearson chi2(1) = 0.3432 Pr = 0.411^N					Pearson chi2(1) = 4.111 Pr = 0.015**			

**Significant at 5% and N = non-significant

Based on the level of food poverty, there was statistically significant (at 5 percent) difference between the two groups (participants and non-participants). The head count indices were 0.37 and 0.191 for program participants and non-participant households, respectively. The poverty gap index was lower for the program participants (0.023) than that of the program non-participants (0.043). And the poverty severity of the program participants (0.012) was 1.9% lower than the non-participants (0.031).

6.6 Food poverty

About 235 Ethiopian Birr measured in per adult equivalent was used as food poverty line, accordingly, 30.6 percent of the households were found to be below the food poverty line with income gap of 6.24 percent and squared poverty gap index of 2.1 percent. As depicted in Table 2 below, the level of food poverty incidence varied from Woreda (District) to Woreda (District). The highest food poverty head count index (0.217) was recorded in Geter Adwa and the least was observed in Tahitay Maichew (0.111). In addition, the poverty gap (0.034) was higher in Geter Adwa and the least was observed in Mereb Leke (0.003).

Table 6: Food Poverty by Woreda level

Woreda	Food Poverty Estimates			Food Poverty Line
	P_0	P_1	P_2	
Geter Adwa	0.217(0.031)	0.034(0.013)	0.012(0.002)	235
Ahferom	0.157(0.021)	0.015(0.004)	0.006(0.003)	235
Kola Temben	0.126(0.022)	0.014(0.004)	0.005(0.003)	235
Lailay Maichew	0.134(0.030)	0.028(0.014)	0.011(0.011)	235
Mereb Leke	0.215(0.012)	0.003(0.002)	0.001(0.001)	235
Population	0.125(0.004)	0.024(0.001)	0.013(0.001)	235

7. Conclusion and Recommendations

7.1 Conclusion

The study specifically revealed that the Productive Safety Net Program (PSNP) intervention has enabled the program participants to retain their assets holdings. The program participants, as a result of the program's intervention, have increased their livestock holdings. The program participants owned more livestock in terms of TLU, than the non-participants. The study revealed that the program has positive and

statistically significant impact on productive assets, durable goods, and household goods. Positive and statistically significant results were obtained for food consumption per adult equivalent and total consumption per adult equivalent (at 1 percent).

Based on the level of food poverty, there was statistically significant difference between the two groups (participants and non-participants). The head count indexes were 0.37 and 0.191 for program participants and non-participant households, respectively. The poverty gap index was lower for the program participants (0.023) than that of the program non-participants (0.043). And the poverty severity of the program participants (0.012) was 1.9 percent lower than the non-participants (0.031). Furthermore, the poverty severity index was lower for program participants. Generally, findings of this study revealed that the impact of the Productive Safety Net Program (PSNP) has positive and statistically significant effect on poverty reduction through increasing households' overall family consumption expenditure and in protecting assets of the rural households.

7.2 Recommendations

Based on the above findings of the study, the following recommendations are made:

- The government should encourage the program participants to re-orient on commercialized dairy and fattening livestock development activities in order to reduce the problem of food insecurity and to improve their income sources.
- Every member of the program participants should be fully targeted into the program so that improved their food insecurity problems and to ensure self-food sufficiency (the program should be individual focused than household based).
- In order to target all the eligible ones, the government should consider reducing the duration of benefits from the program (reducing the duration of program benefits) so as to increase the number of participants within the budget constraints. Thus, the researcher

recommends reducing program participation period from five to four years with series follow ups.

- Most of the program participants were male-headed households relative to the female-headed households. Hence, the program should able to include more female-headed households or at least in the same proportion as that of the male-headed households.

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Appendix 1: STATA program output of the estimation of Propensity Scores for Matching

```
pscore psnpparticip sex age landholding fsize creditacc shocks oxenbb tlubb
edustatus maleadult femaleadult irriland, pscore(p1)comsup logit
**************************************************
Algorithm to estimate the propensity score
**************************************************
The treatment is psnpparticip
 are you a          |
     psnp           |
beneficiary         |
 household          |      Freq.     Percent        Cum.
--------------------+-----------------------------------
        no |        23539.30       39.30
       yes |        36560.80      100.00
--------------------+-----------------------------------
     Total |        600           100.00

Iteration 0:   log likelihood = -137.18596
Iteration 1:   log likelihood = -106.48462
Iteration 2:   log likelihood = -105.26196
Iteration 3:   log likelihood = -105.24285
Iteration 4:   log likelihood = -105.24285

Logistic regression                 Number of obs   =        600
                                    LR chi2(12)     =      31.42
                                    Prob > chi2     =     0.0010
Log likelihood = -105.24285         Pseudo R2       =     0.3274
------------------------------------------------------------------------------
psnpparticip |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
sex |           2.19003    .6301631     3.48   0.001      .954933    3.425127
age |          .0331605    .0253169     1.31   0.190     -.0164597    .0827806
land |          .4538186    .278864      1.63   0.104     -.0927448    1.000382
fsize |          .380879    .1806844     2.11   0.035      .0267441    .7350138
creditacc |     1.000040    .6663582     1.50   0.188     -.1550374    0.221843
shocks |        1.761582    .3482018     5.06   0.000     1.079119     2.444045
oxenbb |         .1021113    .448701      0.23   0.820     -.7773264    .9815491
tlubb |          -.0380292    .1495155    -0.25   0.799     -.3310743    .2550158
edustatus       -.1886385     .5222046    -0.36   0.718     -1.212141    .8348638
maleadult |     -.6735947    .2383953    -2.83   0.005     -1.140841    -.2063485
 femaleadult |       .414577   .2973316     1.39   0.163     -.1681824    .9973363
irriland |             .1237622   .4204877   0.29   0.769     -.7003786    .947903
_cons |               -6.240335   1.745051   -3.58   0.000     -9.660572   -2.820099
------------------------------------------------------------------------------
```

Note: the common support option has been selected
The region of common support is [.04375827, .87441442]

Estimated propensity score

	Percentiles	Smallest		
1%	.1037032	.0535783		
5%	.1340736	.1027383		
10%	.1841699	.1046682	Obs	600
25%	.3095437	.1071762	Sum of Wgt.	600
50%	.5703575		Mean	.56
	Largest	Std. Dev.	.2679227	
75%	.821748	.9502573		
90%	.8968573	.9544894	Variance	.0717826
95%	.9162437	.9568956	Skewness	-.1741254
99%	.9556925	.9744199	Kurtosis	1.660684

****

Step 1: Identification of the optimal number of blocks
Use option detail if you want more detailed output
****

The final number of blocks is 5
This number of blocks ensures that the mean propensity score is not different for treated and controls in each blocks
****

Step 2: Test of balancing property of the propensity score
Use option detail if you want more detailed output
****

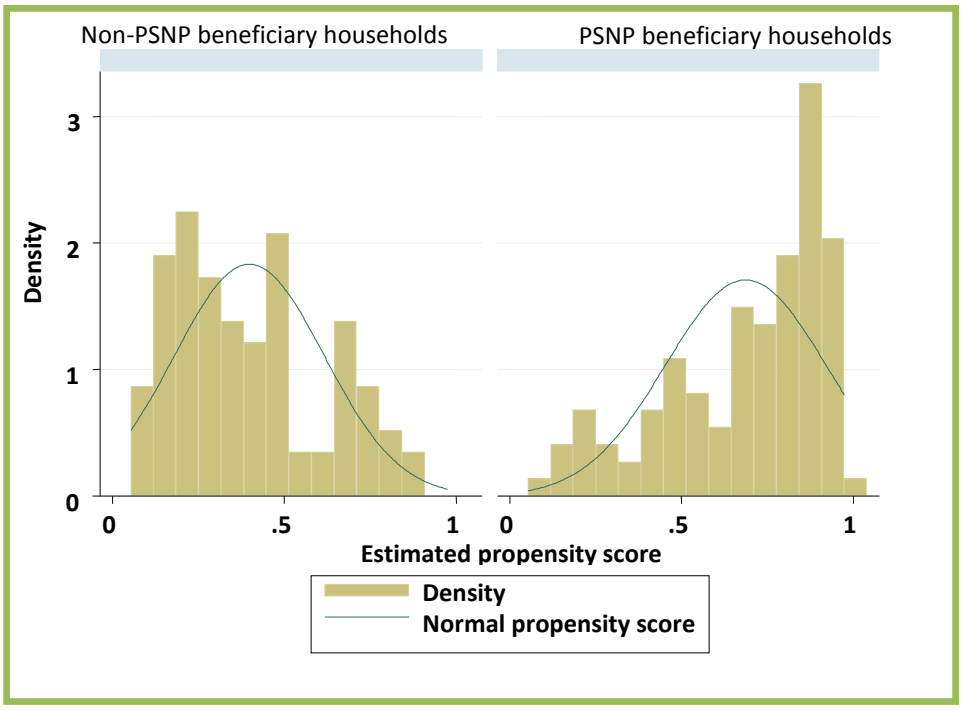
The balancing property is satisfied
This table shows the inferior bound, the number of treated and the number of controls for each block

Inferior of block of pscore	are you a psnp beneficiary household? no	yes	Total
.0535783	59	121	180
.2	3979	118	
.4	2767	94	
.6	66	84	150
.8	44	14	58
Total	235365	600	

Note: the common support option has been selected
****

End of the algorithm to estimate the pscore
****

Appendix 2: Kernel Density graphs of the predicted propensity scores by treatment status



Source: Own Computed from Household Survey Data,2010

Estimating Elasticity of Demand and Production Response for Adoption of Chemical Fertilizers: Tigray, Ethiopia

Menasbo Gebru[1] and Tefera Kebede[2]

Abstract

Agriculture remains the backbone of Tigray's economy. The purposes of the study are to: (1) estimate price elasticity of demand for adoption of inorganic fertilizer at region level, (2) estimate production response to fertilizer adoption (Urea and DAP) and (3) analyse the proxy determinants of demand for inorganic fertilizer. Eighteen –year time series fertilizer demand data and allied macro variables are used for the analysis. Descriptive statistics and multivariate regression are employed as analytical tools. The regression result shows rainfall and one year-lagged agricultural output affect demand for fertilizer positively. On the other hand, fertilizer price and variation in temperature influence demand for fertilizer negatively. The marginal effect shows that for one percent change in fertilizer price, demand for fertilizer (DAP) changes by 6.8 percent in the opposite direction, which is price elastic. Similarly, for one percent change in one-year lagged agricultural output, demand for DAP and UREA change by 0.65 and 0.61 percent, respectively, in the same direction. Reliability of rainfall increases the demand for inorganic fertilizer significantly.

Key words: Fertilizer adoption, elasticity, production, OLS, Tigray.

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1. Introduction

1.1 Background of the study

There is a general agreement that application of modern farm inputs is a precondition for better agricultural productivity and poverty reduction (Quddus et al, 2008). The demand for input derived from demand for product produced through technical characteristics of production function. Inorganic[3] fertilizer is one of the principal farm inputs used in developed and developing countries though its utilization rate is minimal in the latter. For instance, Africa took only two to three percent world fertilizer usage in 1960s. Moreover, the share of Sub-Saharan Africa, except South Africa, was generally less than one percent of world fertilizer application (Quddus et al, 2008). Some studies also reveal that fertilizer use in SSA[4] to some extent grew at an annual rate of 4 percent from 1961 to 2002(Kelly, 2006).

Application of fertilizer differs across crops. Forty percent of fertilizer in SSA is used for Maize followed by Sorghum and Millet (FOA, 2002). African farmers are not in a position to make profit maximizing fertilizer demand decisions as compared to the rest of the world like USA[5] and China. The weak effective demand for fertilizer in Africa mainly emanates from poor analytical framework that does not beyond the simple arithmetic profit maximization (*Kelly, 2006)*.

Persistent land degradation, poor land fertility and poor technology adoption put agriculture at subsistence level in Africa including Ethiopia (Gebremedhin et al, 2006). Ethiopia uses fertilizer for *Teff*, barley and wheat, and15% of the national fertilizer is used for commercial crops (e.g. fruits, vegetables, and sugar cane).In spite of intensive public investment on agriculture, performance of the sector improves only in terms of labour force absorption and foreign exchange earnings (Mellor and Dorosh, 2010).

[3]Interchangeable use with Chemical fertilizer
[4]Sub Sahara African
[5] United States of America

1.2 Statement of the Problem

The Tigray economy is dominated by smallholder agriculture, where farmers have an average landholding of less than or equal to one hectare (Gebregziabher *et al.*, 2012). To improve productivity with the existing land size, especial emphasis is given for adoption of fertilizers at household level. Concerning its utilization intensity, it is low in terms of adoption and coverage. Hagos and Hoden (2002) point out that about 48.8% of Tigray's farmers use inorganic fertilizers. Lack of detailed socio-economic and demographic characteristics of households and their responsiveness towards adoption of fertilizers are considered to be the major factors preventing policy makers from designing strategies to solve the adoption problem. Input and output market imperfections also make lower adoption rate. Demand for fertilizer depends on the need and perception of farmers of their microenvironment at a particular point. But fertilizer price is considered the main determinant factor (Hailemariam, 2012; Hagos and Hoden, 2002).

Fertilizer adoption is sensitive to topography (highland vs midland), types of farmers (different management practices), and seasons (reliability of rain). High agricultural output prices are expected to motivate farmers to adopt productivity enhancing inputs such as improved seeds and inorganic fertilizers but a large number of Tigray farmers are reluctant to adopt this new farming technology.

Even though Hailemariam (2012) estimates that the microeconomic determinants of demand for fertilizer in Tigray, using two rounds of household survey (2001&2010), the study does not substantiate the following key points. First, the result shows two-time data (2001 and 2010) having a 10 year interval and loosely looks at price responses in a yearly basis. Second, there is a methodological gap. The study uses dichotomies choice model (panel Probit model) on the adoption equation and the Tobit model in the outcome equation. Nevertheless, the Tobit model uses the same explanatory variable as the Probit model and lacks exclusion

restriction, i.e. all explanatory variables could not influence adoption and the amount adopted at the same time. Hence, this study aims to fill these gaps.

1.3 Objective of the Study

The general objective of the study is to estimate price elasticity of demand for inorganic fertilizers and production response in Tigray Regional State, northern Ethiopia. More specifically, the study has the following objectives:

1. to estimate price elasticity of demand for adoption of chemical fertilizers at region level,
2. to investigate the production response to fertilizer adoption (Urea and DAP)and
3. to analyze the proxy determinants of fertilizer adoption in Tigray region.

2. Review of Related Literature

2.1 Demand for fertilizer and its determinants

This section discusses a summary of earlier studies on demand for fertilizer and discusses the. Guilloches (1958) formulates a demand function for fertilizer on all crops in the United States from 1911 to 1956 and the results vary among crops. According to Gunjal, et al (1980) demand for fertilizer varies across fertilizer type and crop prices and found out Gunjal, et al (1980) that fertilizer demand for major crops was price elastic. On the other hand, Carman (1979) analyses demand for three fertilizers (Nitrogen, Potash and Potassium) for 11 Western States of USA and the results show that price elasticity of demand varies across states and nutrients. Using Cobb-Douglas production function, Mohodd et al 2005, and Raiz et al (2012) estimate demand for Urea in Bangladesh and result revealed inelastic price for Urea. Moreover, non-price determinants such as production season and agro ecology affect demand for fertilizer. For instance, Africa demands nine kg per ha and Latin America 73 kg per ha while Asian countries use between 100-153 kg per ha (Kelly, 2006). Technical and institutional constrains such

as lack of complementary inputs and poor management practice also affect demand for fertilizer in Africa.

Carman (1979) investigates that crop and fertilizer prices, and land size of specified crops are the predetermined factors for fertilizer adoption. The author also found an inverse relationship between fertilizer price and demand for fertilizer and a direct relationship between fertilizer prices and lagged- output price. Penm and Vicent (1987) found out that in Australia prices were inelastic for phosphate and nitrogenous fertilizer in the short and long run, while demand for nitrogenous fertilizer appears to elastic, especially in wheat application. In general, the price effect on demand for fertilizer differs across fertilizer and crop type (Kelly, 2006). Farm size positively correlates with adoption of fertilizer as larger farmers get higher chances of practicing with fertilizer adoption on some parts of their land without severely threatening the subsistence food requirement (Kelly, 2006; Hailemariam, 2012).According to Salam (1977), there is a positive relationship between farm size and demand for fertilizer while it is negatively related with fertilizer price in Punjab (India). On the other hand, farm income affects demand for fertilizer negatively particularly for non-commercial crop producers in Sub Saharan Africa (World Bank, 2006).

3. Data source and methodology

3.1 The Data

The study uses time series secondary data Fertilizer used by the region is collected from the regional Bureau of Agricultural and Rural Development. Regional rainfall data from 88 stations and 18- year temperature data from 50 stations is collected from the Ethiopia Metrology Agency, Mekelle branch. Population, product price, output of major agricultural products, prices of Urea and price of Dap are collected from CSA[6] and regional Bureau of Agricultural marketing.

[6]Central Statistics Agency

3.2 The Model

The study starts from profit maximization model constrained by quantity of inputs used. Apply FOC[7] and solve for quantity of inputs used at regional level. Following the methodology applied in estimating demand for farm inputs (Carman, 1979; Quddus et al, 2008), we framed the estimation approach in Tigray region and is expressed as fellow:

Cobb-Douglas production function with two inputs (Lobar and Fertilizer).

$$Y = AF^{\alpha}L^{\beta}\mu^{o} \quad \textbf{(1)}$$

Where F refers to fertilizer quantity demand, input and L (labour input[8]),A, refers to production technology, which is constant, and $\mu^{o}$the error term.α and β are the contributions of fertilizer and labour input in the production, respectively.

Moreover, profit function considers:

$$\Pi = P_1Y - P_2F - P_3L \quad \textbf{(2)}$$

Where: F(Fertilizer demand in a given year in quintal), L(labour input), P_1(Output price),
$P_{2(}$ Fertilizer price), $P_{3(}$ Lobar price) Y is agricultural output. Take FOC.

$$\frac{\partial \Pi}{\partial F} \quad and \quad \frac{\partial \Pi}{\partial L} = 0$$

$$\frac{Y}{F} = \frac{P_2}{\alpha P_1 \mu_1} \quad \textbf{(3)}$$

$$\frac{Y}{L} = \frac{P_3}{\beta P_1 \mu_2} \quad \textbf{(4)}$$

[7] First Order Condition

[8] Labour was dropped from consideration in this expression as it is worth nothing to add or to the explanatory power of the estimated equations

In the above relationships, «$_1$ *and*«$_2$ are random error terms. Change the expression of Equation (3) and (4) to natural logarithm form looks as follows (Quduus et al,):

$$\log F = \frac{\log A + \log\left(\frac{P_2}{\sim P_1}\right)(-1) + \log(«_{1-}«_2) - \log\frac{P_3 + \log «_0 - \log «_1}{P_1}}{1 - \sim -} \quad (5)$$

Relation (5) indicates any demand function for fertilizer should incorporate product price, price of fertilizer and other input technological shift and random error term. Based on this, the demand function for fertilizer in the present study specifies using double log form as:

$$lnF_{(\frac{i}{j})t} = \beta_0 + \beta_1 \ln\left(\frac{P_f}{P_c}\right)t + \beta_2 lnHYV_t + \beta_3 lnW_t + \beta_4 lnY_{t-1} + \beta_5 lnT + \beta_6 lnA + \varepsilon_t$$

(6)

Where $lnF_{(i-j)}$= quintal of plant nutrient used in each year, Pf/Pc =ratio of fertilizer price index to five major crops[9] price index, Y_{t-1} =farm output in year t-1 from major crops, HYV =Area under high yield varieties in hectare, W = water availability at farm –gate (mm), A= area under principal crops in hectare, T = trend variable and ε= error term,i and j are unit identifiers of Urea And Dap fertilizer respectively, ***t*** is time identifier.

3.3 Variables description and prior expectations

In line with the empirical findings in developing and developed countries, the study sought a number of explanatory variables in adoption of fertilizer equation for the region. A brief explanation and expected effect are illustrated under this section.

[9]According to CSA, five major staple crops are Wheat, Maize, Barely, Teff, and Sorghum

Quantity of Fertilizer demand (Urea and DAP)*:* It is a dependent variable in the regression model and is expressed in quintals used at regional level in all zones of Tigray from 1995-2012. Determinants of the two fertilizers might differ from one variable to other. Demand function expressed in log-log relationship, thus one percentage change in the explanatory variable results in change in elasticity of demand for fertilizer in the same or different direction to the variable change. If elasticity is greater than unity in absolute value, demand for fertilizer is strongly responsive to variable change while if elasticity is less than one, (inelastic) demand for fertilizer is less responsive to the variable change and exhibits insignificant effect on the overall fertilizer demand (**Carman, 1979).**

Fertilizer price**:** Fertilizer price is considered one cost of agricultural activity and farmers' decision to demand for it or not depends on its market price. Fertilizer price is one of the most determinant factors in the demand for fertilizer, and the higher the fertilizer price, the lower the demand (Hagos and Stein 2002, Hailemariam, 2012, **Carman, 1979).**

Output price**:** Since demand for fertilizer is a derived demand where a farmer would demand more fertilizer that maximizes financial returns from more production. Farmers' profit maximization occurs when marginal cost of last unit of fertilizer applied is equal to the value of marginal returns. Hence, one can suspect that the higher the price of agricultural output using fertilizer, the greater demand for fertilizer input **(Kelly, 2006).**

Lagged farm output**:** One year lagged output is a good indicator of current year demand for fertilizer since farmers develop speculation of farm yield from fertilizer application (the ratio of output to fertilizer used). Therefore, high lagged real farm output per acre has a positive impact on current fertilizer demand (**Carman, 1979)**.

Size of cultivable land (hac**):** This is total potential area for cropping of the region. Although the relationship between size of cultivable land and fertilizer adoption at regional level is an empirical question, one can expect

a direct relationship. Thus the higher the land size used to cultivate, the greater the demand for fertilizer with lower opportunity cost of adoption (Hailemariam, 2012).

Rainfall: Adoption of fertilizer has the risk of early dehydration of the land under cultivation and a high Probability of crop failure. Sufficient reliability of water is a prerequisite to demand for fertilizer. Hence, farmers should demand for more fertilizers during the rainy season (***Admassu, 2004)***.

Temperature**:** In rain-fed agriculture, the weather such as high temperature significantly affects the demand for fertilizer. The optimum temperature for various agricultural products varies. Thus the higher the temperature for the required level of a particular agricultural output, the lower the demand for fertilizer.

Value added of Agricultural sector: The Tigray economy is agrarian. To improve farm productivity, adopting modern fertilizers is very important. Hence, the more agricultural sector value added, the greater demand for modern fertilizer for further productivity enhancement (Kelly, 2006).

4. Analysis and Discussion

4.1 Descriptive Analysis

Agricultural practice in Tigray is subsistence and factors of production are traditional. As a result agricultural output is not adequate to satisfy the food requirement of the region. Lower agricultural productivity is one indicator of poor land use. Although plots of land in different agro-ecological zones of the region are under smallholder[10] cultivation and producing a variety of agricultural products, factor productivity is low (measured as the amount of output per unit of input).

10 Households having an average Land holding size of less than or equal to one hectare (Gebregziabher *et al.*, 2012)

4.1.1 Fertilizer demand of the region

Following the market-based economic system (1991), agriculture has taken the leading role in the Agriculture Development Led Industrialization (ADLI). Adoption of new technology such as fertilizer use at household level is one of the top priorities in the rural development strategy. Even if there has been some progress in agricultural productivity in Tigray region, fertilizer adoption rate is below the amount expected for food security and poverty reduction. Table 4.1 indicates fertilizer demand in Tigray region for eighteen years.

Table 4.1: Fertilizer demand of Tigray region (1995-2012) in quintal

Variable	years	Mean	Min	Max
DAP	18	84802.17	16280	271625
UREAU	18	6618.11	3490	179019
Total	18	145420.3	19770	450644
Percapita_DAP	18	0.024	0.006	0.067
Percapita_UREA	18	0.017	0.001	0.044
Percapita_total	18	0.041	0.01	0.11

Source: BOARD Tigray 2012

The study assesses fertilizer utilization rate (intensity)[11] using quantity demanded and cultivated land size data for the same period(N=18).Table 4.2 presents average intensity of fertilizer use throughout the region and the result shows fluctuates extremely from one year to the next; eg. DAP, 0.15kg/ha in 1998 which increases from 0.081kg/ha(1999)to 0.10kg/ha(2008) and marginal increases range from 0.086kg.ha(2009) to 0.16kg/ha (2012).

[11] computes as the ratio of fertilizer demand in Kg to the cultivable land size(hac)

Table 4.2 Intensity of fertilizer used (Kg/Hac)

Year	Dap	Urea	Total
1995	0.032	0.007	0.039
1996	0.036	0.020	0.056
1997	0.043	0.035	0.079
1998	0.150	0.117	0.267
1999	0.081	0.060	0.141
2000	0.072	0.061	0.134
2001	0.006	0.006	0.012
2002	0.075	0.063	0.138
2003	0.068	0.057	0.125
2004	0.073	0.043	0.117
2005	0.073	0.048	0.121
2006	0.080	0.063	0.143
2007	0.069	0.050	0.119
2008	0.101	0.068	0.170
2009	0.086	0.057	0.144
2010	0.128	0.088	0.216
2011	0.188	0.124	0.311
2012	0.161	0.118	0.279
Average	0.085	0.060	0.145

Source: Own computation based on BOARD data, 2013.

4.1.2 Demand for and Price of Fertilizer

Demand for fertilizer is a derived demand and farm and off farm factors influence it. Farm factors are expressed in terms of previous agricultural output, land size engaged in production, rainfall and temperature while off farm factors are mainly fertilizer prices and off farm income. Price of DAP per quintal on average ranges from 249(1995) to 1453(2012)Birr while price of Urea from Birr179 (1995) to Birr[12]1159(2012).Concerning price growth rate, it increased on average by 483.53% and 547.48% from 1995 to 2012 for DAP and Urea, respectively (result not tabulated). Examining average

price of fertilizer gives a partial analysis about the overall adoption of the input at regional level and incorporating its demand will give a complete picture about the market (see Table 4.3).

Table 4.3: Fertilizer price vs. quantity demand: percentage change (1995-2012).

Year	Dap qty (%)	Dap price (%)	Urea qty (%)	Urea price (%)
1995				
1996	15	81	199	1
1997	13	80	67	1
1998	261	-79	246	-12
1999	-7	-40	-12	-14
2000	-11	1290	2	15
2001	-4	-604	-3	-3
2002	-9	-250	-13	11
2003	1	-256	0	-4
2004	0	1728	-28	32
2005	-12	1763	-1	22
2006	16	327	36	-2
2007	28	1003	18	15
2008	22	4628	14	40
2009	19	3000	17	23
2010	64	-290	69	-3
2011	57	4519	51	37
2012	-21	2996	-21	31
Average	25	1170	38	11

Source: Own computation based on BOARD Tigray data, 2013.

Table 4.3 depicts percentage changes of fertilizer adoption with corresponding percentage changes of price of the two fertilizer types. Demand as well as market price of a particular fertilizer is not consistent across time (increasing and decreasing) but on average price of DAP increased by 1170 percent from 1995 -2012 and quantity demanded changed by 25 percent. Similarly, percentage changes of quantity demanded for Urea rose by 38 percent while percentage changes of its price increased by about 11 percent (1995-2012). Briefly, percentage

changes of price of DAP are by far greater than quantity demanded but percentage of prices of Urea are lower than its quantity percentage changes. However, the trend of quantity demand- price relationship shows positive, which contradicts the law of demand and this might be due to strong government involvement in fixing fertilizer prices which means that the market for fertilizer is imperfect.

4.2 Econometric results

4.2.1 Data use in regression analysis

Prior studies identify general level of profit, input price, output price, price of related inputs as key factors in estimating adoption of inorganic fertilizers. In Tigray region, application of fertilizers has a long history although its utilization is far below compared to other regions. The econometric method is employed as an analytical tool to estimate responsiveness of fertilizer adoption over vector of explanatory variables. The dependent variable is quantity of fertilizer demanded (DAP and Urea) during *the meher*[13] season. To estimate price elasticity of demand and production response of inorganic fertilizers, an effort on data exploration process is made first.

Unit root tests of variables

The nature of the data is time series in which sequence of observations ordered in time with equal space from 1995-2012 and we check the stability of mean and variance of variables over time are checked. If the mean and variance of variables fluctuate consistently, the regression analysis result will end up in spurious results, which means that the result will show correlation of unrelated variables. The standard conclusion that will be drawn from this empirical evidence is in line with macroeconomic time series data that contains unit root problem. It is important to note that in this empirical work, unit root is tested to make sure the rejection of the null hypothesis (no unit root problem). The stationary test shows most of

[13]In Tigray a greater percentage of plots are used during this season and it ranges from June to October/November

the variables used in the regression analysis are stationary after first difference. In other words, coefficient of the lag variable is unity and coefficient of variables in the regression result are different from zero. Thus, variables are co-integrated inorder one **I** (1).Unit root test of variables used in the regression analysis are presented in Table 4.4.

Table4.4: Augmented Dickey Fuller unit root test of variables

Variables	Intercept	trend	ADF Sta. at 5% level of significance		F-statistic	Prob (F-statistic)
DAP_fertilizer	-112.39	19.119	-4.32***	I(1)	10.51	0.002
Urea Fertilizer	-94.14	15.32	-5.83***	I(1)	12.98	0.000
Price DAP	-112.39	19.11	-4.32***	I(1)	10.51	0.002
Price Urea	-94.14	15.32	-5.83***	I(1)	12.98	0.000
Price total Fertilizer	-209.53	34.95	-4.81***	I(1)	12.11	0.001
LandS_culitvable	-8336.42	8979.01	-4.95***	I(1)	12.35	0.001
Output total	-3013	559988.5	-4.527***	I(1)	9.92	0.002
Land_maincrops	17882.94	679.86	-7.46***	I(1)	13.02	0.000
Output_maicrops	278750.0	61738.29	-5.821***	I(1)	15.53	0.000
Land_Teff	3723.70	-492.23	-7.89***	I(1)	17.85	0.000
Land- Maize	17773.41	-1460.58	-4.28***	I(1)	11.16	0.001
Land Sorghum	1319.29	930.23	-7.75***	I(1)	19.04	0.000
Land wheat	-153357.	12153.92	-10.76***	I(1)	90.50	0.000
Out put_teff	663063.9	-45247.53	-9.92***	I(1)	23.46	0.00
Output-Barely	523216.1	-37821.08	-6.57***	I(1)	15.98	0.000
Output-Wheat	14389.94	10242.80	-4.49***	I(1)	12.15	0.000
Output_Maize	267776.9	-17360.16	-5.40***	I(1)	13.17	0.00
Price –Teff	-52.12	11.74	-3.51**	I(1)	4.38	0.029
Price –Maize	-19.59	5.19	-3.87**	I(1)	6.28	0.012
Price -Sorghum	-33.02	7.50	-3.62**	I(1)	4.70	0.023
Price –Wheat	-20.37	6.52	-4.08***	I(1)	8.22	0.004
Rainfall	-1.41		-4.01***	I(1)	11.00	0.001
Temperature	-0.08	0.03	-5.75***	I(1)	15.11	0.000

Note: ** ,***MacKinnon critical values for rejection of null hypothesis of a unit root at 5 and 1 percent respectively.
Source: CSA, BOARD Tigray, Marketing Agency, 2012

Co- integration Test

The stationary test verifies if variables under consideration are stationary at first difference. The next step is to check the long-term relationship between dependent and independent variables using the co -integration-test method. The procedure is straightforward. First, run OLS [14] estimation of dependent (fertilizer quantity used) over independent variables having I (1) and save the residual. Second, test for unit root of the residual at level. Accordingly, the quantity demand for fertilizer (DAP and Urea) regresses on a set of explanatory variables including year (time-trend) and generate the residual. We check the trend of the residual over time whether it diverges or converges its mean from or to zero respectively. The test result rejects the null hypothesis if residual has no unit root problem and the error term converges to its mean value of zero and verifies that variables are co-integrated.

Table4.5: Co- integration test of error term (95%CI)

Adopted fertilizer	ADF test	Decision Ho	Order in integration	Probability
lnDAP	-4.333***	Rejection	I(0)	0.0028
lnUREA	-3.379*	Rejection	I(0)	0.0543

*, *** MacKinnon critical values for rejection of null hypothesis of a unit root at 10 and 1 percent respectively.

4.3 Determinants of Demand for Fertilizer(Adoption Model)

Fertilizer demand equation as specified in Equation (6), estimates for each nutrient and total (Urea &DAP) using ordinary least square. To start with, we convey a simple correlation coefficient matrix on selected explanatory variables to see that multicollinearity is present or not. Test verifies no severe problem of multicollinearity. The statistical significance of various parameters differ widely across variables and most of the signs of the estimated variables have as anticipated the reasonable sign. Following the model specification in Equation (6), we estimate the demand for the two

[14]Ordinary Least Square

fertilizer types commonly used in Tigray. Results are presented in Table 4.6. Note that the model specification of dependent and independent variables is in natural logarithm; hence, regression coefficients measure percentage change of demand for a particular fertilizer provided percentage change in the explanatory variable.

4.3.1 DAP

The estimated coefficients of DAP present on Table 4.6, second column. The signs of all coefficients except price index ratio of fertilizer to price index of major crops are as hypothesized and most coefficients are significant. The multiple coefficient of determination,R^2 indicates that variables included in the model explain over 95.6 percent of variation in quantity demand for DAP. Coefficient for real price index of DAP is relatively large with standard error as it shows in the t-statistics and most of the variables (5 out of 7) are statistically significant at 5% level.

Ratio of Price index of DAP to price index of major crops

The result indicates that demand for DAP is positively related to relative price index ratio of DAP to major crops' price index. The marginal effect shows that for one percentage change in ratio of DAP price index to major crops price index, demand for DAP changes by 6.35 percent(elastic) in the same direction keeping other variables constant. This finding contradicts with the prior expectation and law of demand. The contradiction might come from fertilizer market imperfection of the region because adoption of fertilizer is dominantly practiced through public mobilization (campaign) and the government fixes the price.

Total fertilizer price

According to demand theory, price elasticity of demand for a product (normal goods) is expected to be negative (i.e., as price of a product increases, quantity demanded decreases). Accordingly, Table 4.6 depicts that fertilizer price (DAP and UREA) are negatively related to quantity demanded. Hence, one percentage change in price of DAP and UREA leads

to changes in quantity demanded by 6.799 and 8.88 percent in the opposite direction, respectively. This finding is consistent with a study by Zerfu and Larson (2010) where farmers are sensitive to fertilizer prices. There is a contradiction between descriptive statistics and regression results. In the descriptive analysis, price of fertilizer and fertilizer demanded for the region increase over time while the multivariate analysis result is consistent with the theory. The source of gap is from endogeneity of fertilizer prices in the multivariate analysis where government revises fertilizer prices over time based on import prices, transportation and transaction costs, and price exhibits an exogeneity nature.

Table 4.6: Regression result of fertilizer demand

Dependent variable: Log fertilizer demand (quintal)			
	DAP	**UREA**	**Total (D+U)[15]**
Explanatory variable	**Coef.**	**Coef.**	**Coef.**
ln rainfall	1.18***	1.299***	0.567
ln land size	-0.387	-0.580	0.666*
Drought(T0c)	-2.93	-4.22**	-3.46*
ln Y t-1	0.646***	0.612***	0.812***
ln (D&U)_ PI	6.346***	8.382***	0.75**
ln TFP	-6.799***	-8.885***	-0.396
Ln T	0.068**	0.086	0.033
-cons	-136.25	-167.88***	-69.31
F(7,9)	38.82	5.38	17.44
Prob>F	0.0000	0.0000	0.0000
R-square	0.9588	0.9724	0.9128
Prob>Chi2(1)	0.4462	0.4462	0.3418
Durbin-Watson(7,17)	1.98	1.98	1.788
BIC	0.261	2117	12.9
AIC	-5.571	-5.571	7.144

*** Significant at 1 %, ** significant at 5%, * significant at 10% .Std errors are not reported
Source: Own computation based on BOARD Tigray, Marketing Agency, CSA, 2012.

[15] Urea and DAP

Rainfall

Technically speaking, fertilizers (DAP and UREA) are synthesized from unsaturated hydrocarbon double bond and to make active and reactive with soil bacteria, the double bond should break down through dilution[16]. To complete the hydrocarbon bond dissociation and accelerate reaction with soil bacteria,, availability of enough water is compulsory. That is why adequate rainfall is prerequisite and complementary input for fertilizer adoption.

Examining factors that affect adoption of fertilizers in Tigray region is a timely issue and this study gives a preliminary finding as an input for future research to go in detail at micro level and bring holistic information for policy decision. Table 4.6 depicts a positive relationship between rainfall and adoption of fertilizer. The marginal effect shows that for one percent change in rainfall from a previous year(*meher season*), adoption of DAP fertilizer increases by1.2 percent (elastic) at 1% level of significant .This result is consistent to prior hypothesize and finding of Zerfu and Larson(2010)and (Dercon and Christiansen 2005. IFPRI, 2007, QUDDUS et al, 2008).

Cultivable Land size

Land is one principal input of agriculture. The larger the land size, the better becomes the food security situation. The purpose of this study is not to examine the correlation between cultivable land size and agricultural productivity; it is rather to analyse the responsiveness of fertilizer adoption over agricultural land size. More obstacles of fertilizer use for large land size is risk associated with missing insurance markets. Farmers may rationally choose low productivity approaches that lower investment risks and allow households to diversify limited financial resources instead of purchasing fertilizers with high risk of returns from a large farmland (Zerfu and Larson,

[16]More water helps to break (dissolve) the hydrocarbon double bond to single bond. After finishing the dissociation reaction, the next reaction will be with soil bacteria and additional water is required to facilitate the reaction between the fertilizer nutrient and the soil to fertile the soil.

2010). Accordingly, Table 4.6 depicts a negative relationship between demand for fertilizer (DAP) and farm size but is statistically insignificant. This finding is consistent with (Zerfu and Larson, 2010) and Croppenstedt and Demeke (2003) in Ethiopia and Nkonya et al. (1997) in Tanzania. The negative relationship may arise from the interest of farmers to use smaller land size holdings. As Nkonya et al. (1997)note that farmers prefer to invest more time and effort into their limited size holdings than diluting their resources on large land size that involves risk. Moreover, farmers with larger land size holdings sometimes hedge risks through applying on a smaller proportion of their land, thereby reducing average application rates.

Drought (high temperature)

Optimum temperature is one basic input for crop productivity. The key aspect of this study is to examine the effect of temperature variation from the past to the adoption time of chemical fertilizer, which in turn affects crop productivity. The study uses temperature variation as a proxy variable for weather variability[17], which is manifested by reducing precipitation and increasing temperature above the optimum in a short period of time. In other words, drought explicitly refers to lack of adequate rainfall and increasing surface temperature. The implication of weather variation on adoption of chemical fertilizer is quite negative and this finding reveals an inverse relationship between temperature and fertilizer adoption. Consequently, for one percent change in temperature from a previous year production time (*meher season*), adoption of chemical fertilizer decreases by 2.93, 4.22 and 3.46percent for DAP, Urea and total fertilizer, respectively. More severe decreasing effect of fertilizer adoption prevails on Urea and it is coherent with the dehydration nature of Urea as it

[17]*"The difference between weather and climate is a degree of time. Weather is the day-to-day state of the atmosphere, and its variation over short period (minutes, hours, days, weeks, months and year) whereas climate is statistical weather data at a given place for long period. To determine climate, weather of a locality is usually averaged over a 30-year period. The economic implication of weather is quite unlike to climate change, as they represent essentially different phenomena''(Bezabih et al., 2014)*

accelerates soil dryness. However, demand decreasing effect of temperature on DAP is insignificant and this might be reliable with the feature of DAP which relatively has the potential to retain some moisture of the soil for some extended time as compared to Urea.

4.3.2 UREA

Regression coefficients of Urea are presented in (Table 4.6, column 3). The signs of estimates are in accordance with prior expectations and significant at 5% level of significance. The multiple coefficient of determination indicates that variables include equation has R^2 value of 0.97, which shows overall goodness of fit of the estimated regression model. Autocorrelation is not a severe problem as estimate's ''*d*'' is 1.98 from Durbin-Watson table. The interpretation so far pertinent to DAP applies also for Urea. Reference should be made to Table 4.6 for a better understanding. Moreover, post estimation test of regression results are compatible with the theoretical assumption of OLS.

5. Conclusions and Recommendations

5.1 Conclusions

The estimates of fertilizer demand are in general agreement with prior expectation except ratio of price index of fertilizer to price index of major crops. Coefficients of rainfall, lagged output, temperature are statistically different from zero and results are consistent with theory. To sum up, at aggregate level, as price of fertilizer per quintal changes by one percent, demand for total fertilizer (UERA and DAP) changes by 6.8 percent in the opposite direction. Therefore, total fertilizer price correlates inversely with its demand and the responsiveness is elastic. However, this result contradicts with the reality that fertilizer market operates under closer government intervention and fertilizer price becomes an endogenous variable and makes unrealistic estimation. The entire post estimation tests confirm coefficients are efficient and unbiased estimates of the model.

5.2 Recommendations

For implementing effective fertilizer adoption strategy, investigating the nature and evolution of demand, profile of farm and all contributing factors of technology are very important. Building appropriate understanding of fertilizer adoption is a vital strategy for poverty reduction. From the discussion, fertilizer adoption in Tigray regional state given the 18 -year time series data is relatively low (per-capita demand). Socio-economic, environmental and physical elements are the main determinants of fertilizer adoption. the following recommendations are made to carry out effective adoption of the technology:

1. Prior to adoption of a particular fertilizer type, there is a need go through pre- examination of the eco -system of the plots at a point in time.
2. This study concentrates only to *meher* season fertilizer used, but greater effort is needed to explore in-depth about the trend and factors affecting fertilizer adoption at regional as well as at *wereda* level using of *belg* season also.
3. Household level analysis will give better results of elasticity of demand for fertilizer and this study calls further research in this area.
4. Methodologically, this study uses OLS but fertilizer price is an endogenous variable and applying Instrumental Method of Analysis (IV) may give a much more robust result.

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