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MEASURING SECTORAL INTERDEPENDENCE IN ETHIOPIA: A SOCIAL ACCOUNTING MATRIX (SAM) APPROACH*

Tadele Ferede**

Abstract**

The objective of this paper is to measure the extent of inter-sectoral linkages in Ethiopia using social accounting matrix (SAM). According to the paper, indirect effects enhance interdependence in the Ethiopian economy. When general equilibrium effects are taken into consideration, agriculture is found to be superior, through income and consumption linkages, in terms of stimulating economic growth in the country. Specifically, teff, wheat, maize and coffee have relatively strong linkages with other sectors of the economy. Among the industrial sub-sectors, food processing, metals, beverages, and textiles have strong linkages with the rest of the economy. The paper has also showed that an exogenous increase in the demand for products of agricultural activities has a larger effect on the demand for both labor and capital. Within the industrial sub-sectors, food processing, beverages, and textiles have a strong impact on labor income from an exogenous increase in the demand for the products of these activities. As a result, rural households benefit more than urban households do from an exogenous increase in the products of agricultural activities. This implies that policy interventions that stimulate and increase the incomes of both rural and urban people would generate a significant demand for selected agricultural and manufacturing activities. It can be argued that the agricultural sector cannot be transformed without the development of the modern sector, without which the much desired growth and development cannot be realized. This balanced growth between agriculture and industry has received little attention from policy makers and planners. Thus, it seems reasonable to suggest that the development strategy of the country should recasting of priorities taking into consideration both the agricultural and non-agricultural sectors.

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** Lecturer, Economics Department, Addis Ababa University.

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1. INTRODUCTION

The economies of developing countries are characterized by the predominance of the agricultural sector while the modern sector is virtually underdeveloped. As such, the economic growth of and development of these countries are closely tied with the development of the agricultural sector. In light of this view, most developing countries including Ethiopia have adopted an overall development strategy known as agricultural development led industrialization (ADLI) strategy. The strategy uses agriculture as a springboard for the development of the industrial sector. This is a result of superior growth linkages, via consumption and income effects of agricultural and non-agricultural sectors.

Analysis of the interaction among sectors is regard as the central issue in the debate over the proper role of agriculture and other sectors (Sadoulet & Janvry 1995). Accordingly, the choice of strategic sectors should be based on the capacity of the sectors to generate forward and backward linkages. Social accounting matrix (SAM) is a useful instrument to measure the extent of linkages among sectors. Thus an in-depth treatment of the real interaction among production activities, factors of production and decision-making units is of paramount importance for the short-term analysis of demand management and policy design. In line with this, many studies have been undertaken to measure the magnitude of inter-sectoral linkages since the early 1970s (Keuning and Thorbecke 1992; Lewis and Thorbecke 1992; Dorosh and Haggblade 1993; Kone and Thorbecke 1996; Pradhan and Sahoo 1996; Pyatt, G., Roe and Associates 1977; Hassen 1994; Skountzos 1990). In the Ethiopian case, Taye (1991) applied SAM-based multiplier analysis to three Ethiopian villages with the objective of measuring the extent of economic linkages and the impact of government policies on the study areas. Indeed, this study is the only type of its kind in Ethiopia to date though it is limited to village level. The author failed to decompose the village level SAM-multiplier into separate effects, that is, direct and indirect effects. The decomposition is important to see the relative strength of direct and indirect multiplier effects. As such, the analysis of these types of interconnections among sectors and institutions is important for designing consistent macroeconomic as well as sectoral policies and strategies in the country.

The objective of this paper is, therefore, to measure and decompose the magnitude of inter-sectoral linkages in the Ethiopian economy. The rest of the paper is organized as follows. Section two deals with method; section three discusses results; and the final section presents conclusions and policy implications.

2. METHOD

Social accounting matrix (SAM) is the main analytical tool that has been widely used to examine the interaction of the various sectors in an economy. There are two main functions of SAM. It can provide a general database for organizing information about the economic and social structure of an economy. SAM can also be considered as a model. To move from a social accounting matrix to a multiplier model, it is not uncommon to classify accounts indicated in the SAM into endogenous and exogenous accounts. This characterization of SAM is used to identify the impact of a change in endogenous accounts as a result of a prior change in exogenous accounts. Multiplier analysis will be used here as a modeling application of SAM. In doing so, the 1995/96 social accounting matrix developed by Tadele (2000) will be used. This social accounting matrix consists of fifteen production activities, two factors of production (labor and capital), three institutions (namely, rural households, urban households, and government), one combined capital account, and the rest of the world.[1] This method has the advantage of capturing both the direct and indirect effects of any exogenous changes that occur in an economy.

Endogenous accounts consist of production factors, rural and urban households, and production activities. Households are categorized either into urban or rural location. The location criterion for disaggregating households is useful since it determines the level of employment, sources of income, consumption pattern, and access to other basic services. In a standard SAM structure, households receive income from factors of production, receive transfers (from within households, i.e. inter-household transfers, government or rest of the world). They also spend on goods and services (i.e. consumption expenditure) save, pay taxes to government, and make transfers. On the other hand, exogenous accounts include government, combined capital account, and the rest of the world. Government is viewed as an interventionist institution which formulates policies and uses instruments, such as taxes, subsidies, and the like to achieve its objectives. A capital account is also assumed to be exogenous because it does not have effects over other accounts in the short-run. This model assumes that there is under capacity utilization of resources in the Ethiopian economy implying that any increase in exogenous demand is met by an increase in output. Due to the existence of idle capacity in the economy, in the short-term, no additional investment is required to bring output-income increase in the economy resulting from an exogenous demand increase.[2] Finally, the rest of the world account is considered exogenous since Ethiopia is considered to be a small open economy and hence, its macroeconomic policies cannot influence world aggregates (Table 2.1).

Table 2.1: Partitioning of Social Accounting Matrix

Payments\ Receipts	**Endogenous Accounts**			**Exogenous Accounts**		
	Production Factors 1	Institutions 2	Activities 3	Government 4	Capital Acc 5	ROW 6
Production Factors Institutions Activities	Endogenous Transactions			Injections		
Government Capital Account Rest of the World	Leakages			Exogenous Transactions		

Source: Vandemoortele, 1987.

Thus, by partitioning the SAM, the effects of changes in the exogenous accounts on the endogenous accounts of the economy can be captured. This can be done by a multiplier analysis corresponding to the SAM-based linear fixed coefficient.

Following the conventional approach of input-output models, the relationship between endogenous and exogenous accounts can be expressed as:

$$y = A_n y + x \qquad \textbf{(1)}$$

where y, A_n and x are, respectively, a vector of incomes of endogenous accounts, a matrix of average propensities and a vector of incomes of exogenous accounts.

Equation (1) can also be expressed as:

$$y = [I - A_n]^{-1} x = M_a x \qquad \textbf{(2)}$$

where M_a is termed as the social accounting multiplier since it measures the income accruing to endogenous accounts as a result of a unit injection, i.e. it shows how a change in any element of the exogenous accounts will affect the endogenous accounts.

The aggregate multiplier matrix, M_a, can be expressed as a product of three multiplier sub-matrices (Pyatt and Round, 1979).

$$M_a = M_3 M_2 M_1 \quad \textbf{(3)}$$

Hence, equation (6) can alternatively be expressed as:

$$y = M_3 M_2 M_1 x \quad \textbf{(4)}$$

The first multiplier matrix M_1 captures transfer effects, that is, it measures the effects of transfer within endogenous accounts of the economy and it is given by:

$$M_1 = \begin{bmatrix} I & 0 & 0 \\ 0 & (\mathrm{I} - \mathrm{A}_{22})^{-1} & 0 \\ 0 & 0 & (\mathrm{I} - \mathrm{A}_{33})^{-1} \end{bmatrix} \quad \textbf{(5)}$$

Such multipliers show how an injection into a specific set of endogenous accounts will affect this same set of accounts due to the interrelationships that exist between the endogenous variables that make up this set of accounts. The second multiplier M_2 measures the cross-effects or the "open-loop" effects and shows the interactions among and between the sets of endogenous accounts. Formally, this sub matrix is given by:

$$M_2 = \begin{bmatrix} I & \mathrm{A} & \mathrm{A}_{13} \\ (I - A_{22})^{-1} A_{21} & \mathrm{I} & \mathrm{B} \\ \mathrm{C} & (\mathrm{I} - \mathrm{A}_{33})^{-1} \mathrm{A}_{32} & \mathrm{I} \end{bmatrix} \quad \textbf{(6)}$$

where $A = A_{13}(I-A_{33})^{-1}A_{32}$, $B = (I-A_{22})^{-1}A_{21}A_{13}$ and $C = (I-A_{33})^{-1}A_{32}(I-A_{22})^{-1}A_{21}$

This sub matrix measures the influence of an injection into one part of the system upon other parts. As it is vividly indicated in equation (3), there is no direct relationship between, for instance, production activities and the incomes of institutions. A unit increase in the demand for production activities will increase factorial incomes by A_{13}. If, on the other hand, the expenditure of production factors increase by a unit, then institutional incomes will increase by A_{21}. The total interaction within the institutional accounts due to a rise in the institutional incomes by A_{21} is $(I-A_{22})^{-1}A_{21}$. As a result, the aggregate increase in institutional incomes because of a unit increase in the exogenous demand for production activities will be $(I-A_{22})^{-1}A_{21}A_{13}$. This multiplier is termed as the "open-loop" multiplier in the literature.

Finally, matrix M_3 measures the full circular effect of an injection into the economy, traveling through the economic system back to its initial point. Mathematically, this sub matrix is given by:

$$M_3 = \begin{bmatrix} D & 0 & 0 \\ 0 & E & 0 \\ 0 & 0 & F \end{bmatrix} \qquad \textbf{(7)}$$

where $D = \{I-A_{13}(I-A_{33})^{-1}A_{32}(I-A_{22})^{-1}A_{21}(I-A_{22})^{-1}A_{21}\}^{-1}$,

$E = \{I - (I-A_{22})^{-1}A_{21}(I-A_{33})^{-1}A_{32}\}^{-1}$ and

$F = \{I - (I-A_{33})^{-1}A_{32}(I-A_{22})^{-1}A_{21}(I-A_{22})^{-1}A_{21}A_{13}\}^{-1}$

This multiplier matrix captures "closed-loop" effects, for example, from production activities to factors of production, to institutions and back to production activities in the form of consumption demand and so on.

This method will be used to measure the size of inter-sectoral linkages in the Ethiopian economy. The discussion of the results is presented in the following section.

3. DISCUSSION OF RESULTS

In the previous section, attempts have been made to show how SAM could be transformed into a model. In this section, the social accounting multipliers are presented in the context of the Ethiopian economy.

3.1 Impact of an Exogenous Injection into Households

In this subsection, an attempt is made to present the effects of an exogenous injection into the incomes of households, both rural and urban, on production activities, factors of production, and households themselves. Table 3.1 below depicts these effects.

Table 3.1: Effects of Exogenous Injection into the Incomes of Households

Destination Injections	Origin of injections		Destination Injections	Origin of injections	
	Rural HHs	Urban HHs		Rural HHs	Urban HHs
Teff	0.242	0.191	Non-Metals	0.008	0.006
Wheat	0.094	0.082	Metals	0.185	0.165
Maize	0.143	0.123	Labor	1.42	1.098
Coffee	0.026	0.023	Capital	0.978	0.814
Food processing	0.094	0.063	Rural HHs	2.600	1.285
Beverages	0.178	0.126	Urban HHs	0.884	1.694
Textiles	0.125	0.075			

Source: Own computation

An exogenous increase in the incomes of households has an effect on the three endogenous accounts including the households themselves. It is clear from Table 3.1 that a one million Birr injection into rural households increases the demand for *teff*, metals, beverages, maize, and textiles by 0.242, 0.185, 0.178, 0.143 and 0.125 million Birr, respectively. The largest impact is felt on the demand for *teff* followed by metals and beverages. With regard to the factors of production, the same injection into rural households increases the demand for labor and capital, after successive interactions among endogenous accounts, by 1.42 and 0.978 million Birr, respectively. The incomes of labor have increased by more than the initial injection. Finally, the same magnitude of exogenous injection into the rural households increases the incomes of these households by 2.60 million Birr and that of urban households by 0.884 million. It is important to note that rural household incomes increase by more than double the initial injection. This is due to the fact that the initial injection first increases the demand for outputs of production activities thereby necessitating the employment of additional factors of production, which in turn increases incomes of production factors. This higher factor income would be distributed between rural and urban households. Due to increased income, household demand for goods and services increases and production activities use more factors of production and the effect continues.

The same amount of injection, on the other hand, into the urban households brings a 0.191, 0.165, 0.126, 0.123 and 0.075, million Birr increase in the demand for *teff*, metals, beverages, maize, and textiles, respectively. An injection of the same magnitude increases labor income by 1.098 million Birr and capital income by 0.815 million Birr. An exogenous increase in urban households' income increases the income of these households by 1.694 million Birr and rural income by 1.285 million Birr due to the trickledown effect. In this case, the incomes of both types of households have increased by more than the initial injection as opposed to the case of rural households where the exogenous injection increased only the incomes of these households by more than the initial injection.

3.2 Effects of an Exogenous Injection into Production Activities

The multipliers for factors of production show the amount by which incomes of production factors would increase for a one million Birr increase in the demand for goods and services. Similarly, the household income multipliers indicate the amount by which household incomes would increase for a one million Birr increase in the demand for the products of production activities. If there is an exogenous injection into each of the production activities, each sector increases or stimulates activities of other sectors of the economy. For instance, if one million Birr is injected into *teff*, then it results in an increment of 0.25 million Birr on *teff* itself, 0.083 on food processing, beverages, textiles and metals, respectively. These exogenous changes in sectoral demand increase the production of the whole economy by 4.32 million Birr. If, instead, the same amount is injected into coffee, it brings about an increment of 0.024 million Birr on coffee itself, 0.082 million Birr on food processing, 0.156 million Birr on beverages, 0.106 million Birr on textiles, and 0.174 million Birr on metals. In the aggregate, this injection increases the entire production 4.25 million Birr. If the same amount is injected into the industrial sub-sectors, such as food processing, it results in an increment of 0.149 million Birr on *teff*, 0.241 million Birr on wheat, 0.137 million Birr on itself, and 0.505 million Birr on other services. This injection will increase the total production by 3.727 million Birr.

It is interesting to note that the accounting multipliers for production activities show that relatively larger figures are observed for *teff*, wheat, maize, food processing, and textiles. This indicates that any exogenous increase in the demand for the outputs of activities mainly affects production of items of necessity. A similar result has been obtained for Sir Lanka, Zaire, and Greece (for more details see the aggregate multiplier matrix in Table 3.5).

Table 3.2 below shows the effects of exogenous changes in the demand for products of goods and services on factors of production. These multipliers increase the incomes of production factors for a one million Birr increase in sectoral demands. It was found that all agricultural and industrial activities, with no exception, have a significant impact on the incomes of labour and capital. Among the industrial sub-sectors, food and textiles have a greater effect on labor than on capital.

Table 3.2: Impact on Factor Employment of Exogenous Change in Demand

Description	*Teff*	Wheat	Maize	Coffee	Food Processing	Beverages	Textiles	Non-metals	Metals
Labor	1.909	1.951	1.875	1.872	1.245	0.498	1.004	0.506	0.231
Capital	1.274	1.160	1.239	1.272	0.905	0.436	0.786	0.471	0.17

Source: Own computation

Among all activities, agriculture is the most important stimulant in generating factor income as compared to industrial sub-sectors.

It is also important to assess the impact of exogenous changes in sectoral demand on the level of the incomes of households. Table 3.3 provides the multiplier effects of such changes.

Table 3.3: Household Income Multipliers for Production Activities

Description	*Teff*	Wheat	Maize	Coffee	Food processing	Beverages	Textiles	Non-metals	Metals
Rural HHs	2.132	2.108	2.089	2.103	1. 394	0.609	1.180	0.635	0.268
Urban HHs	1.131	1.082	1.105	1.121	0.758	0.349	0.656	0.372	0.147

Source: Own computation

Of all the activities, *teff* generates the largest increase for rural household income, followed by wheat and coffee. Concerning industrial activities, food processing and textiles generate relatively higher incomes for rural households. For urban households, the largest increase in income is generated from *teff*, followed by coffee and maize. Exogenous demand changes in *teff* will increase total household income by 3.26 million Birr, out of which the share of rural households is 65.3% and that of urban households 34.7%. It is important to clarify at this stage how demand shock in *teff* raises household income. It is transmitted through cross and circular multiplier effects, that is, through indirect effects. First, a positive demand shock in *teff* leads to higher factor employment which tends to increase factor income. This higher income is then reflected in the rise of household incomes and this additional income increases the household consumption of both agricultural and industrial goods as well as services. This induces more production more by paying higher income for production factors which increases household income further and the effect continues. There are also transfer effects between households. For instance, if there is an increase in the income of rural households, the income of urban households will increase because of a transfer from the former to the latter. It is clear that rural households benefit more from the exogenous demand changes in *teff* than their urban counterparts. If there is an exogenous increases in demand for coffee, incomes of rural and urban households increase by 2.103 and 1.121 million Birr, respectively, while total household income increases by 3.22 million Birr out of this, rural households claim 65.2% and urban households 34.8%. This shows that rural households are still the main beneficiaries of the injection as in the case of *teff*.

If the injection is in one of the industrial sub-sectors, such as food, the respective incomes of rural and urban households would increase by 1.394 and 0.758 million Birr. This injection would bring an increase of 2.152 million Birr in the total household incomes.

3.3 Effects of an Exogenous Injection into Production Factors

In this subsection, will deal with the impacts of an exogenous injection into the production factors on the factors of production themselves, on household incomes, and on activities.

Table 3.4: Effects of an Exogenous Injection into Factors of Production

Result of a one million Birr injection into

Destination of injections	Origin of injections		Destination of injections	Origin of injections	
	Labour	Capital		Labour	Capital
Teff	0.231	0.216	Non-Metals	0.007	0.007
Wheat	0.088	0.091	Metals	1.255	0.175
Maize	0.133	0.139	Labor	1.894	0.181
Coffee	0.024	0.025	Capital	2.346	2.307
Food processing	0.087	0.078	Rural HHs	0.942	1.064
Beverages	0.10	0.166	Urban HHs	1.933	1.295
Textiles	0.152	0.114			

Source: Own computation

As indicated in Table 3.4, *teff* has increased by 0.231 and 0.216 million Birr due to a one million Birr injection in to labor and capital incomes, respectively. In fact, all activities increased by less than the initial injection from an exogenous increase in labor income.

A one million Birr injection in labor brings a 2.346 million Birr additional income on labour itself and 0.942 million Birr increment in the capital income. Thus, labor is most affected by the exogenous increase in the income of it.

It is clear from the basic structure of SAM that incomes earned by factors of production are distributed to households according their factor endowments.

Because of this relationship, any exogenous change in the incomes of production factors affects the incomes of households. The incomes of rural and urban households increase by 2.307 and 1.064 million Birr, respectively, due to a one million Birr injection in labour income. On the other hand, when the same amount of injection is made into capital, incomes of rural and urban households increase by 1.933 and 1.295 million Birr, respectively. In either case, rural households benefit more from the exogenous increase in the incomes of production factors.

3.4 Analysis of Linkages

Various sectors in an economy are interdependent in taking inputs from each other and in supplying inputs to each other. According to Herischman, the former is known as backward linkage and the latter forward linkage (Sadoulet and Janvry, 1995). Backward linkage measures the proportion of an activity's input that represents purchases from other activities, while forward linkage measures the proportion of an activity's output that is used as inputs by other sectors. Before the 1970s, linkages were measured based on input-output matrix. Linkages based only on inter-activity flows have been the main reason for ignoring agriculture while giving due emphasis to industrialization. Since peasant agriculture, the dominant activity in most developing economies, is the producer of primary commodities, it has weak backward linkages. And since it is the producer of final commodities, it has low forward linkages. However, since the 1970s the inclusion of income and final consumption linkages into input-output matrix made significant the key role of agriculture in development (ibid: 273). In developing economies like Ethiopia, the largest segment of the population is dependent on agriculture. As such, agriculture is considered to be the main source of household incomes and expenditures. Expenditures of agricultural households can induce industrialization under the force of effective demand. Thus, when we consider the linkage effects brought by agricultural incomes, agriculture appears as strong as industry, and induces a relatively more equitable distribution of growth (ibid: 291).

Accordingly, the *i*th column sum of the aggregate multiplier matrix (Table 3.5) gives the total input requirement from all sectors which is the economy-wide backward linkage of this sector. The *i*th row sum of the aggregate multiplier matrix indicates the total forward linkage of the *i*th sector. These linkage types can be used for assessing the degree of interdependence of a given sector. Looking at the aggregate multiplier matrix, *teff* has got the highest backward linkage (10.764), followed by wheat (10.665). Food processing and textiles have also strong backward linkages indicating their high dependence on domestic sources and less dependence on imported materials. Surprisingly, backward linkages with the magnitude of less than 5 occur in beverage (4.148), non-metals (4.471), and metals (2.352). This is clearly a sign of their high import dependence. As indicated earlier, non-metals and metals have high import-intensity with magnitudes of 0.70 and 0.90, respectively. These sub-sectors have weak integration with the rest of the domestic economy.

With regard to forward linkages, it can be gleaned from the same table that *teff* has got the highest forward linkage (4.305) followed by metals (3.620), beverages (3.382), and textiles (3.157). Among the industrial sub-sectors, metals have got the highest forward linkages followed by beverages.

The total linkage, which is the composite of the multipliers of different accounts, is useful in assessing the aggregate effect expected at the national level. The individual effects can be calculated and they are called partial forward or backward linkages. Looking at the accounts of production activities, wheat has the largest partial backward linkage (4.364) followed by *teff* (4.319). Among the industrial sub-sectors, food processing has the largest partial backward linkage (3.727) followed by textile (3.610). Between households, rural households have the largest partial backward linkage effects of (3.483). And also between factors of production, labor has higher partial backward linkage (3.286) as compared to capital.

It is also important to consider the degree of partial forward linkages per account. In this respect, the partial forward linkages of factors of production are 45.152 while that of households and production activities are 48.363 and 67.626, respectively. The production activities have the largest partial forward linkages, followed by households. The sum of these linkages gives us the economy-wide linkage.

Table 3.5: Size of Intersectoral Linkages

		1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL FWLK
Labor	**1**	2.346	1.255	1.417	1.097	1.908	1.951	1.875	1.872	1.214	0.498	1.004	0.506	0.231	25.751
Capital	**2**	0.941	1.894	0.977	0.814	1.274	1.160	1.239	1.272	0.882	0.436	0.786	0.470	0.170	19.401
Rural HHs	**3**	2.307	1.933	2.599	1.285	2.132	2.108	2.089	2.103	1.394	0.609	1.180	0.635	0.268	30.910
Urban HHs	**4**	1.064	1.295	0.884	1.694	1.131	1.082	1.105	1.121	0.758	0.349	0.656	0.372	0.147	17.453
Teff	**5**	0.231	0.216	0.242	0.191	1.250	0.217	0.217	0.219	0.149	0.065	0.124	0.068	0.028	4.305
Wheat	**6**	0.091	0.088	0.094	0.082	0.089	1.231	0.087	0.087	0.241	0.048	0.050	0.030	0.012	2.682
Maize	**7**	0.138	0.133	0.143	0.122	0.134	0.131	1.151	0.132	0.089	0.039	0.075	0.041	0.017	3.007
Coffee	**8**	0.025	0.024	0.026	0.023	0.024	0.024	0.024	1.024	0.017	0.007	0.014	0.008	0.003	1.362
Food processing	**9**	0.087	0.078	0.094	0.063	0.083	0.081	0.081	0.081	1.137	0.153	0.047	0.038	0.014	2.534
Beverages	**10**	0.166	0.152	0.178	0.126	0.158	0.155	0.155	0.156	0.104	1.096	0.089	0.049	0.020	3.382
Textiles	**11**	0.114	0.100	0.125	0.075	0.107	0.105	0.105	0.106	0.071	0.031	1.629	0.035	0.014	3.157
Non-Metals	**12**	0.007	0.007	0.008	0.006	0.007	0.007	0.007	0.007	0.005	0.002	0.004	1.003	0.001	1.114
Metals	**13**	0.181	0.175	0.185	0.165	0.176	0.172	0.172	0.174	0.116	0.052	0.099	0.055	1.023	3.620
Total BWLK		10.071	9.597	9.441	7.776	10.764	10.665	10.547	10.616	7.974	4.148	7.236	4.471	2.351	161.141
Partial BWLK-FP		3.286	3.149	2.393	1.911	3.182	3.111	3.114	3.144	2.096	0.934	1.790	0.976	0.401	29.488
Partial BWLK-HHs		3.371	3.227	3.483	2.978	3.263	3.190	3.193	3.224	2.152	0.958	1.836	1.008	0.415	32.301
Partial BWLK-PA		3.414	3.221	3.564	2.886	4.319	4.364	4.239	4.248	3.727	2.256	3.610	2.487	1.535	43.869

Source: Own computation

Note: FWLK-Forward linkage; BWLK- Backward linkage; FP-Factors of production; HHs-Households; PA-production Activities.

3.5 Decomposition of the Aggregate Multiplier Matrix

The total multiplier can be decomposed into transfer multiplier matrix (M_1) open loop multiplier matrix (M_2) and closed loop multiplier matrix (M_3) that is, $M= M_3\ M_2 M_1$. This can also be expressed in additive form as M= I+T+O+C, that is, the aggregate multiplier is the sum of initial injection, transfer effect, open-loop effects, and closed-loop effects.

3.5.1 Transfer Multiplier Matrix (M_1)

This sub-matrix captures the effects of an account on itself via direct transfers within a module. It is also known as own direct effects. The first block diagonal of this submatrix is an identity because there are no transfers between factors of production. The second block diagonal captures the multiplier effect resulting from direct transfers between households. Finally, the third block diagonal measures the multiplier effects of inter-industry transfers, which are usually known as the Leontief inverse. The result of this submatrix, which indicates selected rows and columns, is given in Table 3.6.

The transfer multiplier effects between households are small. The table indicates that a one million Birr transfer to rural households increases their income by 0.001 million Birr, while the income of urban households increases by 0.028 million Birr. If the same amount of money is transferred to urban households, their income increases by a small amount (0.001 million Birr) and the income of rural households increases by 0.0177 million Birr. Looking at the total transfer effect, one can observe that rural households experience a greater transfer effect than urban households.

A look at inter-activity transfers, the third block diagonal, shows that textile depicts the largest degree of interdependence within the entire economy, followed by food processing. By the classical Leontief inverse, the industrial sub-sectors have strong integration with the rest of the economy. This is so because this inverse takes into account only the input-output module and does not consider the feedbacks coming from income and consumption linkages. When the agricultural sectors are evaluated on the basis of this inverse, their linkages are very small implying a weak integration with the rest of the economy. This is not surprising since the agricultural sector is the producer of primary commodities.

Table 3.6: Transfer Multiplier Matrix -M_1=INV (I-A0)

		1	2	3	4	5	6	7	8	9	10	11	12	13
Labor	**1**	1	0	0	0	0	0	0	0	0	0	0	0	0
Capital	**2**	0	1	0	0	0	0	0	0	0	0	0	0	0
Rural HHs	**3**	0	0	1.000496	0.017653	0	0	0	0	0	0	0	0	0
Urban HHs	**4**	0	0	0.028129	1.000496	0	0	0	0	0	0	0	0	0
Teff	**5**	0	0	0	0	1.028064	8.59E-08	1.67E-07	3.91E-08	0.00254	0.000302	1.64E-06	3.09E-05	9.01E-06
Wheat	**6**	0	0	0	0	1.9E-05	1.144163	1.2E-05	2.82E-06	0.182868	0.021735	0.000118	0.002226	0.000648
Maize	**7**	0	0	0	0	1.87E-08	6.09E-09	1.01993	2.77E-09	0.00018	2.14E-05	1.16E-07	2.19E-06	6.38E-07
Coffee	**8**	0	0	0	0	9.17E-08	2.99E-08	5.79E-08	1.000395	0.000883	0.000105	5.71E-07	1.07E-05	3.13E-06
Food processing	**9**	0	0	0	0	0.000113	3.66E-05	7.11E-05	1.67E-05	1.082813	0.128696	0.0007	0.013183	0.003839
Beverages	**10**	0	0	0	0	2.07E-06	6.94E-07	1.32E-06	3.24E-07	0.000123	1.049578	0.000149	0.000563	0.000107
Textiles	**11**	0	0	0	0	1.87E-05	6.13E-06	1.18E-05	2.81E-06	0.000528	0.000395	1.569672	0.002901	0.000719
Non-Metals	**12**	0	0	0	0	8.61E-06	2.82E-06	5.44E-06	1.29E-06	0.000216	0.000154	0.000149	1.001217	0.000318
Metals	**13**	0	0	0	0	2.13E-06	7.4E-07	1.37E-06	3.55E-07	0.000235	0.000202	0.000329	0.000972	1.000156
Sum		**1**	**1**	**1.028625**	**1.018149**	**1.031432**	**1.145659**	**1.02223**	**1.001239**	**1.560887**	**1.293342**	**1.764069**	**1.475296**	**1.117014**

Source: Own computation

3.5.2 Open-loop Multiplier Matrix (M2)

This sub-matrix shows how an external income injection brings a change in endogenous demand, which transmits throughout the system without returning to its original injection. This sub-matrix is also known as cross-effects or extra group effects. In Table 3.7 below, selected rows and columns of this submatrix are presented.

Looking at the intersection of accounts of production factors and household accounts one can see the effects of a change in incomes of factors of production on the allocation of incomes over households. It is vividly shown that rural households benefit more from an increase in labor income than their urban counterparts. On the other hand, urban households gain slightly higher from a rise in capital income than rural households.

The intersection of household accounts and production activities shows that impacts of a change in the incomes of the former is reflected on the structure of the latter. It is clear that rural households spend a larger proportion of their additional income on the products of *teff*, followed by beverages and metals. On the other hand, urban households spend a significant amount of their additional income on the products of metals, followed by *teff.*

The effects of a change in the structure of activities on the incomes of production factors can be examined by looking at the intersection of the two accounts. It is to be noted that the incomes of labor are highly influenced by increased production of agricultural activities. In other words, increased agricultural production significantly affects labor income (for more details see Table 3.6).

Table 3.7: Open-loop Multiplier Matrix -$M_2=(I+A^*+A^{*2})$

		1	2	3	4	5	6	7	8	9	10	11	12	13
Labor	**1**	1	0	0.437673	0.315711	0.600381	0.599999	0.6	0.597441	0.120784	0.064993	0.124174	0.047263	0.052915
Capital	**2**	0	1	0.286028	0.263855	0.355437	0.236674	0.34268	0.374043	0.144321	0.113614	0.136426	0.100057	0.037869
Rural HHs	**3**	0.781874	0.502028	1	0	0.647862	0.587941	0.641159	0.654903	0.168332	0.107912	0.165892	0.090683	0.062368
Urban HHs	**4**	0.24442	0.521285	0	1	0.332029	0.270026	0.325286	0.341009	0.106093	0.075166	0.10176	0.066959	0.03452
Teff	**5**	0.071623	0.066677	0.073853	0.056784	1	0	0	0	0	0	0	0	0
Wheat	**6**	0.027625	0.028101	0.02644	0.028444	0	1	0	0	0	0	0	0	0
Maize	**7**	0.042145	0.042049	0.041042	0.041139	0	0	1	0	0	0	0	0	0
Coffee	**8**	0.007511	0.007815	0.007039	0.008213	0	0	0	1	0	0	0	0	0
Food processing	**9**	0.028024	0.022731	0.031778	0.013002	0	0	0	0	0	0	0	0	0
Beverages	**10**	0.052802	0.045109	0.057919	0.030756	0	0	0	0	0	0	0	0	0
Textiles	**11**	0.037466	0.027776	0.044726	0.010209	0	0	0	0	0	0	0	0	0
Non-Metals	**12**	0.002231	0.002103	0.002278	0.001841	0	0	0	0	0	0	0	0	0
Metals	**13**	0.054508	0.056301	0.051437	0.058468	0	0	0	0	0	0	0	0	0

Source: Own computation

3.5.3 Closed-loop Multiplier Matrix (M_3)

This sub-matrix measures the effects of an exogenous injection into an endogenous account on itself after a series of interactions in the system. It also captures circular effects together. It is termed as circular or inter-group effects or own-indirect effects. Selected rows and columns are presented in Table 3.8.

The indirect impacts of a change in an account can be observed by looking at the intersection of that account with itself. In this way, the factor accounts revealed that the own-indirect effects of labor are substantial. With regard to the redistribution of income over households, it appears that the indirect effects on the rural households are not only significantly large but also by far greater than urban indirect effects. Hence, rural households benefit more from the own- indirect effects. Finally, the third block diagonal depicts the indirect effects of activities on themselves. The indirect effects of *teff*, metals, and beverages are found to be substantial as compared to other sectors.

Table 3.8: Closed-loop Multiplier Matrix -M_3= Inv(I-A*^{3})

		1	2	3	4	5	6	7	8	9	10	11	12	13
Labor	**1**	2.344137	1.253161	0	0	0	0	0	0	0	0	0	0	0
Capital	**2**	0.939562	1.893371	0	0	0	0	0	0	0	0	0	0	0
Rural HHs	**3**	0	0	2.560751	1.23689	0	0	0	0	0	0	0	0	0
Urban HHs	**4**	0	0	0.835046	1.676757	0	0	0	0	0	0	0	0	0
Teff	**5**	0	0	0	0	1.215186	0.189446	0.212343	0.218527	0.059019	0.039524	0.058095	0.032508	0.020379
Wheat	**6**	0	0	0	0	0.085947	1.075482	0.084792	0.087313	0.023686	0.015903	0.023301	0.013096	0.008149
Maize	**7**	0	0	0	0	0.130104	0.114323	1.128362	0.132161	0.035817	0.024035	0.03524	0.019787	0.012333
Coffee	**8**	0	0	0	0	0.023584	0.020699	0.023265	1.023961	0.006507	0.004372	0.006401	0.003601	0.002237
Food processing	**9**	0	0	0	0	0.080044	0.070728	0.079013	0.081242	1.021794	0.014538	0.021472	0.011935	0.007566
Beverages	**10**	0	0	0	0	0.153635	0.13557	0.151638	0.155967	0.041945	1.028021	0.041312	0.02302	0.014532
Textiles	**11**	0	0	0	0	0.103777	0.091912	0.102464	0.105294	0.028126	0.018713	1.027726	0.015344	0.009798
Non-Metals	**12**	0	0	0	0	0.006736	0.005928	0.006647	0.006841	0.001849	0.001239	0.00182	1.001019	0.000638
Metals	**13**	0	0	0	0	0.17064	0.149799	0.16834	0.173363	0.047065	0.031614	0.046297	0.02604	1.016184

Source: Own computation

4. CONCLUSIONS AND POLICY IMPLICATIONS

The main objective of this study was to measure inter-sectoral linkages in the Ethiopian economy. The analysis was carried out using the social accounting matrix (SAM) -based multiplier. The advantage of this method is that it captures both the direct and indirect effects of any exogenous changes. Based on the SAM-multiplier analysis, the following are the main conclusions and policy implications.

First, regarding the effects of exogenous changes in the incomes of households, the main features can be presented as follows. It is found that an exogenous increase in the incomes of rural households would generate a significant demand for *teff*, followed by metals, beverages, maize, and textiles. Similarly, an exogenous increase in the incomes of urban households would generate relatively more demand for the products of *teff*, followed by metals, beverages, maize, and textiles. In other words, a huge excess demand exists for *teff* both in urban and rural areas. This finding has far-reaching implication for the choice of a development strategy. However, stimulating incomes of urban households does not exert a substantial influence on production activities. Relatively speaking, stimulating the incomes of rural households generates a better demand for goods and services.

The effects of exogenous increases in the incomes of rural households would raise the incomes of the households by more than 100% of the original increase but has less impact on the incomes of urban households. An exogenous increase in the incomes of urban households, on the other hand, significantly raises the incomes of both rural and urban households though the incomes of the latter are raised by less than the initial exogenous increase. This indicates that whichever type of household obtains the initial injection, the incomes of both tend to increase. However, if the issue of income inequality is taken into account, stimulating incomes of urban households is preferable since it increases the incomes of both types of households with little difference.

Second, taking both direct as well as indirect or induced effects, the agricultural sector in general and *teff*, wheat, and coffee in particular have a strong integration with the entire economy. An exogenous increase in the demand for products has a significant impact on the demand for both factors of production. Specifically, an exogenous increase in the demand for products of agricultural activities has a larger effect on the demand for both labor and capital. Within the industrial sub-sectors, only food and textiles have a strong impact on labor from an exogenous increase in the demand for the products of these activities. This implies that labor absorption in these two sectors is much sensitive to product demand changes. In the agriculture sub-sectors, employment of factors of production is also influenced by changes in product demand. As a result of this, any exogenous increase in the product demand would bring additional income to both types of households. However, rural households benefit more than urban households do from an exogenous increase in the products of agricultural activities. Moreover, an exogenous change in the demand for food and textiles would also have a significant effect on the incomes of rural households.

With respect to policy implications, increasing incomes of both rural and urban people would produce a substantial demand for goods and services thereby creating self-sustained economic growth in the country. It is important to note that transformation of the rural sector cannot be achieved without the development of the modern sector and hence, it is equally critical to promote the non-agricultural sector. This balanced growth between agriculture and industry has received little attention from policy makers and planners. As such, strengthening the linkages between agriculture and other sectors and agents is essential if agricultural production is to play an important role in the economic development of Ethiopia. Thus, it seems reasonable to suggest that the development strategy of the country should recast priorities taking into careful consideration both agricultural and non-agricultural sectors.

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NOTES

[1] The full description of the 1995/96 SAM and the main sources of information for constructing it are available in Tadele (2000). The SAM shows the various flows, sectoral disagregation as well as aggregates of the different economic agents.

[2] There are also other assumptions of the SAM model including constant relative prices, incremental injections which are the same at the margin and on average as well; average propensities which are linear and fixed in the short-run, and elastic supply. This model is demand driven and hence, Keynesian in spirit.

PRIORITIZATION METHODOLOGY FOR PLANNING NEW ROAD PROJECTS IN DEVELOPING COUNTRIES*

Alemayehu Ambo**

Abstract

The objective of this paper is to develop an alternate methodology to prioritize new road projects in developing countries for future detailed economic and preliminary engineering studies. To date, an effective and efficient methodology has not been employed and the selection and prioritization of new road projects has largely relied on assumptions rather than a systematic quantification of road project attributes. The ***proposed methodology*** *is not as complex and sophisticated as those developed for industrialized countries.* ***It is rather*** *designed to efficiently and effectively handle data that are commonly available in developing countries.*

A hypothetical data set of variables commonly available in studying developing countries for road projects was used to test the proposed methodology. The same data were also used to test five existing methodologies that were developed in industrialized countries for making decisions on projects, investments, strategic plans, etc and comparative analyses were conducted on the results. The proposed methodology produced identical project rankings as the ***two existing*** *methodologies* ***and*** *closely correlated with the third methodology but was* ***weakly*** *correlated with the fourth methodology. The fifth methodology was found to be the workable given the data set. The alternate methodology was proved to be a valuable screening tool to assist developing countries.*

Keyword(s): Multicriteria decision making; New road projects; Attributes; Weights.

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** 104-780 Montgomery Street., Fredericton, New Brunswick E3B 2Y1, Canada, e-mail: angtata@yahoo.com

1. INTRODUCTION

Road transport is vital in developing countries where ***the majority of the people live in rural areas about 75 percent of the people are engaged in traditional agriculture although, value added from agriculture is low compared to other sectors.*** However, the road density (km of road per km^2 of area) is still very low and as a result, limited access to agricultural areas has become one of the major inhibiting factors to exploit rural resources.

Most road projects in developing countries are ***financed*** by regional banks like the African Development Bank, the Asian Development Bank and the Inter-American Development Bank; by multilateral development banks like the World Bank and the European Bank for Reconstruction and Development; and multilateral financing institutions like the Nordic Development Fund. Securing funds from lending and granting agencies require a thorough analysis of project prioritization as well as detailed appraisal studies. Beneficiaries are required to produce well-prepared studies with defendable results. Normally, road project studies begin at the planning stages of identification and prioritization, before intensive feasibility studies are carried out. This paper focused on the planning aspect of new road project studies.

There are different economic, social and political factors that are considered during the planning stage of new road projects in developing countries, and one factor could be more important than the other regarding the national interest. The economic factors could be important to a country as compared to social or political factors and there could even be different degrees of importance amongst the economic factors under consideration. In addition, the purpose of a road can differ from one locale to the other or from one country to the other depending on economic and social resources. In developing countries, new roads may be constructed for one or a combination of the following: transportation of agricultural surplus, distribution of food in deficit areas, provision of access to people in remote areas, exploitation of forest and livestock resources, regional integration, etc.

Based on the above, this ***paper*** deals with the prioritization of new road projects and marshaling them into queue for future rigorous economic and engineering feasibility studies. In this regard, sufficient effort has not been done to develop a plausible methodology in developing countries**,** although a significant amount of new road network is required. This ***paper*** is meant to contribute in this direction. It is to be noted that different models, such as the Highway Development and Management Tool (HDM-4), have been established for use in developing countries at the planning and programming stages of existing road projects. ***But this model applies to new road projects, not to the existing ones, which has not been given attention in developing countries*.**

2. EXISTING MULTI-CRITERIA DECISION MAKING APPROACHES IN DEVELOPED COUNTRIES

There have been a number of research studies undertaken regarding multi-/multiple criterion decision making models (MCDM) based on data and arguments typically available for developed countries. Triantaphyllou (2000) considered different MCDM methods and found the following five to be the most widely used in developed countries:

Weighted sum model (WSM),
Weighted product model (WPM),
Analytic hierarchy process (AHP),
Elimination and choice translating reality (ELECTRE), and
Techniques for Order Preference by Similarity to Ideal Solutions (TOPSIS).

The following sections provide an outline of these approaches.

Weighted Sum Model (WSM)

In respect of WSM, Triantaphyllou (2000) stated that if there are m alternatives and n criteria, the best alternative is the one that satisfies the expression:

$$A^{*}_{WSM\text{ - }score} = \max_i \sum_{j=1}^{n} a_{ij} w_j \qquad \text{for } i=1,2,3,\ldots, m$$

where: $A^{*}_{WSM\text{-}score}$ is the WSM score of the best alternative, n is the number of decision criteria, a_{ij} is the actual value of the i-th alternative in terms of the j-th criterion, and w_j is the weighty of importance of j-th criterion.

Triantaphyllou further stated that 'additive utility assumption' governs this model, i.e. the total value of each alternative is equal to the sum of the products. WSM can be used without any difficulty with single-dimensional cases where all the units are the *same (e.g. dollars, feet, seconds). However, the difficulty emerges when it is applied to multi-dimensional MCDM problems. In this regard, Triantaphyllou concluded that the additive utility assumption is violated when different units are combined.*

Weighted Product Model (WPM)

Regarding the weighted product model (WPM), the following equation was established by Triantaphyllou:

$$R(A_K/A_L) = \prod_{j=1}^{n} (a_{kj} / a_{lj})^{w} j$$

where: n is the number of criteria, a_{ij} is the actual value of the i-th alternative in terms of the j-th criterion, and w_j is the weight of importance of the j-th criterion.

As stated by Triantaphyllou, WPM is similar to WSM except that WSM uses addition while WPM deals with multiplication. In WPM, if the term $R(A_K/A_L)$ is greater than or equal to one, then A_K is more desirable than A_L. The best alternative is the one that is greater than or at least equal to all other alternatives. *Triantaphyllou further stated that since the structure of WPM eliminates any units, it can be used in single- and multi-dimensional MCDM with the advantage of using relative values instead of actual ones.*

Analytic Hierarchy Process (AHP)

According to Triantaphyllou the analytic hierarchy process (AHP) model decomposes a complex MCDM problem into a system of hierarchies with the final structure dealing with m x n matrix where, m is the number of alternatives and n is the number of criteria. In this case, the matrix is constructed by using the relative importance of the alternatives in terms of each criterion. The best alternative is:

$$A^{*}_{AHP-score} = \max_i \sum_{j=1}^{n} a_{ij} w_j \quad \text{for i = 1,2,3, ... , m}$$

As stated by Triantaphyllou, the difference between WSM and AHP is that the former uses actual values while the latter most rely on relative values. In addition, the vector

(a_{ij}, a_{i2}, a_{i3}, ..., a_{in}) for each i is the principal eigenvector of an n x n reciprocal matrix which is determined by pairwise comparisons of the impact of the m alternatives on the i-th criterion.

Elimination and Choice Translating Reality (ELECTRE)

Triantaphyllou says that the ELECTRE method focuses on "outranking relations" with pair-wise comparisons using separate alternative criteria. For example, under two alternatives A_i and A_j, the outranking relationship between the two describes that even when the i_{th} alternative does not dominate the j_{th} alternative quantitatively, the decision-maker may still take the risk of regarding a_i as better than a_j. This means that one alternative is dominated by another which makes it excel in one or more criteria while remaining equivalent in other criteria. However, Triantaphyllou noted that since the method yields a system of binary outranking relations between alternatives where the system is not necessarily complete, the method is sometimes unable to identify the most preferred alternative, only producing a core of leading alternatives. Regardless of the above shortcomings, the method has a clear view of alternatives by eliminating less favorable ones which is convenient when there are decision problems that involve a few criteria with a large number of alternatives.

Techniques for Order Preference by Similarity to Ideal Solutions (TOPSIS)

According to Triantaphyllou, TOPSIS was developed as an alternative to the ELECTRE method. The basic concept of TOPSIS is that the selected alternative should have the shortest distance from the ideal solution and the farthest distance from the negative-ideal solution in a geometrical sense. The method assumes that each criterion has a tendency of monotonously increasing or decreasing utility with easy definitions of ideal and non-ideal solutions. Under this method, a normalized decision matrix is constructed first (the same as under ELECTRE method) followed by a weighted normalized decision matrix. Then, ideal and negative-ideal solutions are determined followed by separation measures. The best alternative is the one that has the shortest distance to the ideal solution.

Saaty (1980) proposed the AHP method in decision making in order to determine strengths with which various elements in one level influence the elements on the next higher level so that the relative potency of the impacts of the elements of the lowest level on the overall objectives can be computed. He described the development of weights to be associated with individual activities, based on group quantified judgments and said that if there are n activities (C_1, C_2, ..., C_n), the quantified judgments on pairs of activities (C_i, C_j) are represented by n-by-n matrix. Saaty further stated that, there are two rules for entries of elements in the matrix: rule one says a_{ij} is the reciprocal of a_{ji}, and rule two says, if C_i is judged to be of equal importance to C_j, then, both a_{ij} and a_{ji} will be equal to 1. Finally, the weights and entries are treated to develop selection criteria. Saaty proposed crude estimates of vector calculation as follows:

i) Add the elements in each row and normalize them by dividing each sum by the total of all the sums, so that the results add up to unity. The first entry of the resulting vector is the priority for the first activity; the second entry for the second activity, and so on.
ii) Take the sum of the elements in each column and form the reciprocals of these sums. Divide each reciprocal by the sum of the reciprocals to normalize them so that thus add to unity.
iii) Divide the elements of each column by the sum of that column and the elements in each resulting row and divide this sum by the number of elements in the row. This is a process of averaging out the normalized columns.
iv) Multiply the n elements in each row and take the nth root normalize the resulting numbers.

Pomerol and Barba-Romero (2000) also dealt with a number of multi-criteria decision making models. They stressed the absence of a recognized rule for qualitative criteria and thus, proposed normalization procedures. They stated that if evaluation of m alternatives are given by a_{ij} for a given criterion j, a normalization procedure will transform the vector (a_{1j}, a_{2j}, ..., a_{mj}) into a normalized vector (υ_{1j}, υ_{2j}, ..., υ_{mj}) using one of the following four procedures:

Procedure 1: $\upsilon i = \dfrac{a_i}{\max a_i}$ procedure 2: $\upsilon_i = \dfrac{a_i - \min a_i}{\max a_i - \min a_i}$

where : $0<v_i\leq 1$ $0\leq v_i\leq 1$

Procedure 3: $\frac{a_i}{\sum a_i}$ Procedure 4: $\frac{a_i}{(\sum_i a^2{}_i)^{1/2}}$

where : $0<v_i<1$ $0<v_i<1$

Pomerol and Barba-Romero further suggested that the interpretation of Procedure 1 is made by considering the percentage of maximum ai; Procedure 2 as percentage of range (max a_i - min a_i); Procedure 3 as percentage of the total sum, and procedure 4 as the i^{th} component of unit vector. After normalization, weights (w_i's) are calculated with the sum of 1. Finally, by applying the weighted sum model, evaluations are made such that $R(a_i) = \sum_j w_j a_{ij}$, (i=1,2, ..., m) and the chosen alternative a_i will be the one which gets the highest value of $R(a_i)$. If there is a tie, either one can be taken.

3. MCDM APPLICATION IN THE PLANNING OF NEW ROAD PROJECTS IN DEVELOPING COUNTRIES

Application of MCDM in Developing Countries

MCDM models can incorporate both qualitative and quantitative data. As stated above, the three general factors that are employed in the selection of development projects are: Alternatives which focus on road project; criteria which are attributes of road projects such as resources potential; and factor weights. The first two are quantitative in nature while the third one is qualitative. Generally, the decision making process involves five stages: road project identification, establishment of attributes, development of weights, analyses and decision making.

Road Project Identification

This activity is usually undertaken by government and public agencies. Agricultural offices, both public and private rely on road infrastructure to transport farm inputs to and outputs from development centers. Relief agencies require road infrastructure to transport emergency food and other commodities to affected areas. Regional administrative offices require public transport to provide access to the people in remote areas and to foster regional integration. Potential road projects are identified by designated government offices taking into account all these activities.

Establishment of Attributes

This section deals with the identification of relevant criteria which provide the basis for project evaluation and the quantification of attributes. Common national economic, social and other criteria can be established for designing all road projects. Although these criteria differ from country to country, they are more or less generic for most rural road projects. In developing countries, roads may be required to transport one or a combination of the following: subsistence/cash crop surplus to market centers, relief supplies to deprived areas, passengers to their destinations, and forest and livestock surplus to industries and consumption centers. Roads may also be needed for purposes of regional integration which could be entirely political.

Once appropriate criteria are identified, pertinent government agencies can undertake the quantification work. Agricultural institutions can estimate cash and subsistence crop as well as livestock and forest reserve potentials; relief agencies and non-government organizations can calculate the prevalent and long-term nutrient requirements in food deficient areas; statistical offices can estimate the number of people in project areas; and mapping institutions can estimate how far identified project areas are located from the nearest urban centers.

The next step is to establish weighing factors for each criterion. This is difficult due to the subjective nature of the task. Judgments could be inappropriate due to bias and misunderstanding of the facts. Ideally, the national interest must be the ultimate objective. Weights should be given for each attribute/criterion after a careful comparison with others. In general, all attributers are not considered to have equal values. For example, a country can be in need of foreign currency and thus exportable agricultural produce such as coffee and cocoa may be valued more than other agricultural produce such as wheat, maize, etc. On the other hand, the concern of a country may be the political strengthening of the nation; thus, regional integration may be given a higher priority. Thus, weights can be assigned to each attribute based on the particular need of a developing country or region.

However, reasonable estimates can be developed if knowledgeable and unbiased individuals are involved in the task. As stated by Souder (1980), a Delphi method can be employed since the opinions of several experts can sometimes be 'averaged' to cancel out the errors/biases of individual predictions. Similarly, Nutt (1984) noted that a Delphi survey systematically solicits and collates judgments to form a group consisting of different organizations. Accordingly, participants can be selected from government organizations, universities and private agencies. Experts from the offices of finance, central planning, statistics, transport, agriculture, industry, trade and relief agencies can represent governments; economists, statisticians and researchers can represent higher academic institutions; and traders, transport operators, consumers and farmers can represent private stakeholders.

According to Nutt, a series of questionnaires can be used. The initial questionnaire asks general questions with subsequent questionnaires built on the responses to the preceding questionnaire. Offices of central planning and road authority can be mandated to manage the study. Weights can be absolute or normalized values. The analyses can be done by road authorities/ministries of transport, systems analysts or consultants and the study can be monitored by a steering committee. Once the study is completed, decisions can be taken jointly by the offices of road agencies/ministries of transport, central planning agencies and higher level policy makers.

Proposed Alternate Methodology (AM)

An alternate methodology (AM) is developed considering the requirements of developing countries with a focus on the resource types that are commonly utilized in those regions. The methodology focuses on attributes of new road project with the allocation of weights to prioritize and streamline the projects for future detailed economic and engineering studies. The approach developed through this paper is stated below:

Assumptions:

(a) Let P denote a set of identified new road projects,

(b) P is composed of a finite number of n alternatives, thus,

$$P=(x_1, x_2, ..., x_n)$$

(c) Let A denote a set of attributes

(d) A is composed of a finite number of m attributes. Thus, B represents the attributes of the subject roads with m number of attributes. Thus,

$B=(B_1, B_2, ..., B_m)$.

Next, weights are allocated. For example: w_1 for attribute B_1, w_2 for attribute B_2 and so on until w_m for B_m. Thus, normalized weights would be:

$$w_2 + w_2 + ... + w_m = 1 \quad \textbf{(1)}$$

(Note: The values of w'_s can be whole numbers and the sum can be greater than one provided that the ratios between them remain the same).

Then, weights are distributed among road projects based on the magnitude of attributes. The road projects and attributes are illustrated in the matrix below:

Projects → **Sum of Attributes**

Attributes

∴

x_{11}	x_{12}	...	...	x_{1n}	$\sum_{j=1}^{n} x_{1j}$
x_{21}	x_{22}	...	...	x_{2n}	$\sum_{j=1}^{n} x_{2j}$
...	...	...	...	...	...
x_{j1}	x_{j2}	...	...	x_{jn}	$\sum_{i=1}^{n} x_{ij}$
...	...	...	...	...	...
x_{m1}	x_{m2}	...	...	x_{mn}	$\sum_{j=1}^{n} x_{mj}$

For each cell, a score is calculated based on the following formula:

$$V_{ij} \frac{x_{ij}}{\sum_{j=1}^{m} x_{jn}} w_j \quad \textbf{(2)}$$

where: $i = 1,2,3, ..., n$
$j = 1,2,3, ..., m$
w = weights

Subsequently, all scores for each road project are summed up as follows:

$$P_1 = \sum_{j=1}^{m} v_{1j} = v_{11} + v_{21} + \ldots + v_{m1}$$

$$P_2 = \sum_{j=1}^{m} v_{2j} = v_{12} + v_{22} + \ldots + v_{m2}$$

... ...

$$P_n = \sum_{j=1}^{m} v_{ij} = v_{1n} + v_{2n} + \ldots + v_{mn}$$

On the basis of this calculation, the project with the highest aggregated score will be selected to be the first for detailed feasibility study. This methodology is intuitive and can be utilized without difficulty by experts in developing countries. The methodologies formulated for use in industrialized countries are more complex and mathematically sophisticated, requiring trained experts, currently scarce in developing countries. In addition, most of the existing MCDM models cannot be applied in developing countries without modification.

Analyses and Comparison of Results

Data which were postulated to describe the attributes of various road projects are presented in Table 1. The attributes are the major criteria that are normally considered during road project evaluations in developing countries.

MCDM analyses were carried out using the proposed alternate methodology (AM). The results generated by AM were compared with those calculated using the WSM, WPNM, AHP, Saaty and TOPSIS methods. The ELECTRE method was not used since TOPSIS is simply an improved version of it. In addition, as mentioned by Trantaphyllou, the ELECTRE, method yields a system of binary outranking relations between the alternatives where the system is not necessarily complete and sometimes it is unable to identify the most preferred alternative only producing a core of leading alternatives. Thus, the EL/ECTRE method has not been used for the purposes of comparison.

Five new road projects were considered with seven economic attributes. The weights are random values based on assumed importance of the attributes. The values in brackets (in Table 1) are randomized figures whose sum equals 1. Analyses were done using the AM method considering both randomized and non-randomized weights.

Analyses were carried out using the following six methods: Alternate Methodology (AM), Weighted Sum Model (WSM), Weighted Product Model (WPM), Analytic Hierarchy Process (AHP), Saaty and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). The proposals by Saaty described above as (a), (b) and (d) do not work using this data. This is because (a) and (b) involve addition of attributes which is impossible in this case, since for example, crop surplus and population cannot be added together. Similarly, (d) is not workable since it involves the multiplication of attributes which result in values of zeros because of the "0" values provided in the data. The results incorporating values and rankings are shown in Table 2.

As shown in Table 2, AM (non-normalized) and AHP produce identical results, WSM and TOPSIS produce different results from the former two. It was not possible to conduct analyses using WPM because WPM utilizes ratios of attributes. Ratios cannot be produced with "0" values of denominators. WSM produced different values from AM and AHP because the degree of magnitudes of attributes were not considered. Instead, multiplications of weights and attributes are considered while AM and AHP apply weights after respective attributes have been divided by the corresponding sums. The relative weights of the attributes within each project alternative need to be calculated and should be used as a mechanism of prioritization. This is so because the relative magnitudes of attributes within projects can be measure and incorporated.

In the case of TOPSIS, the distances for ideal and negative-ideal solutions were measured from the maximum and minimum values, respectively, based on a normalized decision matrix. The model, however, considers benefit and cost/loss criteria as fictitious alternative to measure solutions which do not usually appear in attributes of road projects. Ranking under AM, AHP and Saaty (iv) are similar.

Spearman rank correlations were calculated using Anderson et al. (1981) to measure the degree of closeness between the rankings. The correlation between AM/AHP/Saaty (iv) and WSM was 0.2 which is weak, the correlation between AM/AHP/Saaty (iv) and TOPSIS was 0.65 which is reasonably strong while the correlation between WSM and TOPSIS was -0.55 which is negatively correlated indicating that the ranking are opposite to the ranking of AM/AHP/Saaty (iv), under the given data.

Table 1: Hypothetical Projects and Corresponding Attributes

Attributes	Projects					Weight (w)
	A1	A2	A3	A4	A5	
Subsistence Crop Surplus (ton)	100000	75000	30000	0	0	4 (0.16)
Subsistence Crop Deficit (qts.)	0	0	0	60000	30000	3 (0.12)
Population	150000	200000	100000	75000	45000	4.5 (0.17)
Cash Crop Surplus (qts)	25000	35000	50000	30000	100000	5.0 (0.19)
Forest Reserve (m^3)	65000	80000	45000	15000	10000	3.5 (0.13)
Livestock (no. of cattle)	250000	300000	150000	500000	450000	3.5 (0.13)
Regional Integration (distance from nearest urban centre in km)	350	500	750	1000	1200	2.5 (0.10)

Table 2: Score and Ranks of Hypothetical Road Projects

Project	Models												
	AM			WSM		WPM		AHP		Saaty (c)		TOPSIS	
	Value		R	Value ('000)	R	Value	R	Value	R	Value	R	Value	R
A1	0.211*	5.47	2	325	4	NW	NW	5.47	2	0.775	2	0.11	1
A2	0.235	6.04	1	392	3	NW	NW	6.04	1	0.852	1	0.11	1
A3	0.152	3.96	5	228	5	NW	NW	3.96	5	0.551	5	0.51	4
A4	0.199	5.19	4	552	2	NW	NW	5.19	4	0.731	4	0.50	3
A5	0.205	5.34	3	563	1	NW	NW	5.34	3	0.734	3	0.52	5

* Based on Normalized weights + Based on Non-Normalized weights, NW= Not Workable, R=Rank
(Note: The results under Saaty (c) are the same with results under AHP/Non-Normalized weights under AM divided by the number of attributes which is 7 in this case.)]

4. CONCLUSIONS

In developing countries, appropriate prioritization methodologies for new road projects are not yet developed. The methodology proposed in this paper helps to streamline potential road projects for future detailed economic and preliminary engineering feasibility studies in developing countries. Using typical variables important to road projects in developing countries, a series of analyses were conducted utilizing the proposed alternate methodology (AM) and contrasted with the existing models developed specifically for developed countries. The existing models utilized in the analyses are: Weighted Sum Method (WSM), Weighted Product Method (WPM), Analytic Hierarchy Process (AHP), Saaty (iii) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS).

The WPM model was found to be the workable since it includes "0"s as denominators in its calculations. The results under WSM were different from AM since comparisons amongst the attributes within each road alternative were not conducted as the model proposes. The results under TOPSIS were also different because this method requires data describing benefit and cost/loss criteria which are not common in road project attributes in developing countries. The results under AM (non-normalized) and AHP were identical.

Regarding rankings, AM, AHP and Saaty (iii) produced similar results. AM, AHP and Saaty (iii) are plausible for use in developing countries although the last two are more sophisticated requiring greater effort. Saaty (iii) is the same as AM (non-normalized) and AHP except that it proposes values to be divided by the number of attributes. AM produced normalized as well as non-normalized values. It is simple to use and does not require sophisticated computer utilization as proposed by Saaty and Triantaphyllou. AM can easily handle data normally used in developing countries with no complication.

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OFF-FARM EMPLOYMENT AND INCOME INEQUALITY: THE IMPLICATION FOR POVERTY REDUCTION STRATEGY*

Tassew Woldehanna and Arie Oskam*****

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Abstract

This study in Tigray, Northern Ethiopia, using micro data collected from a sample of households asses the contributions of farm and off-farm income sources to the over all income inequality. Some interesting results are obtained. Due to entry barriers, relatively wealthy farm households dominate the most lucrative rural non-farm activities such as masonry, carpentry and petty trade. This has widened the income inequality in rural areas. The main sources of inequality are non-farm activities such as non-farm skilled wage work and non-farm self-employment. Since the present public works program favors the poor, it reduces the income inequality that exists in the rural areas. If off-farm employment become the main source of income inequality in rural areas, its role in the alleviation of poverty will be very limited. Therefore a policy reform is required to manage the redistribution effect of expanding economic activities into off-farm employment. In order to reduce the income inequality effect of diversifying income sources into non-farm activities, the underlying elements that hinder participation of poor households in non-farm activities such as credit constraints and lack of skill, have to be tackled by providing credit and technical training to the poor. Provision of information the public on the labor market could also be helpful to reduce the transaction cost of searching for non-farm jobs. Moreover improving rural infrastructure can reduce spatial income inequality.

***Keywords**: Income diversification, off-farm employment; entry barrier; income inequality, policy reform, Northern Ethiopia*

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** Assistant Professor**,** Department of Economics, Addis Ababa University, Corresponding author.
Tel/ Fax 251 1 553504; e-mail: wtassew@econ.aau.edu.et; Tassew.Woldehanna@WUR.NL
*** Professor of Agricultural Economics and Rural Policy Group, Wageningen University, Netherlands.

1. INTRODUCTION

Farmers in developing countries are often encouraged by policy makers to diversify their income sources into off-farm activities so that poor farmers could supplement their farm income, and reduce income inequality and poverty in rural areas.

After the collapse of the Derg regime, the focus of the Ethiopia government has been to reduce poverty through expansion of farm and off-farm employment (TGE 1994). Promotion of off-farm employment has also been given particular emphasis in the poverty reduction strategy paper (PRSP) of Ethiopia (MoFED 2002). This effort will have a stronger impact on poverty if poor farmers diversify their income sources into off-farm activities. If, however, there are entry barriers in to the labor market, off-farm employment may not reduce income inequality among farm households. This may also prevent it from reducing poverty substantially.

The incentive to diversify income sources into off-farm activities is stronger for poor than for rich farm households because the relative return to off-farm work is greater for the poor than for the rich. The risk aversion motive to diversify income into off-farm activities declines as the wealth of farm households increases, if risk aversion is negatively related with wealth (Newbery and Stiglitz 1981). However, if there are entry barriers to and rationing in the labor market, diversifying income into off-farm activities will be more difficult for the poor than for the rich farm households (Reardon 1997). A credit (liquidity) constraint may make it difficult for poor farm households to finance investment (such as equipment purchase or rent, skill acquisition, capital for initial investment and a license fee) that is required to participate in off-farm activities. Community level barriers can also exist that prevent farm households from participating in off-farm activities. Due to poor infrastructure there is further limited labor market integration (Sadoulet and de Janvry 1995). Absence of labor market integration leads to rationing of off-farm jobs in some communities. Lack of infrastructural facilities may restrict the movement of labor between communities or may make it costly to move to towns. If off-farm activities are risky and correlate positively with farm income, risk averse poorer farm households may not enter into off-farm activities. As a result, off-farm employment may worsen rather than lessen income inequality. If off-farm employment increases income inequality, its role to reduce poverty will be very limited.

Given the general lack of studies on off-farm activities, analyzing the relationship of various off-farm activities to overall income inequality is crucial for a better targeting of programs designed to alleviate poverty. The objective of this paper is, therefore, to analyze the relative importance of different types of off-farm and farm activities to overall household income and income inequality. The total farm household income is decomposed into various categories of farm and non-farm incomes. The income categories used are crop income, livestock income, off-farm self-employment, off-farm wage employment (paid food for work, non-farm manual wage employment and non-farm skilled wage employment) and non-labor income. The relative contributions of these income sources to overall income inequality are assessed using the G*ini decomposition method* (Lerman and Yitzhaki 1985).

The rest of this paper is organized as follows. The nature of off-farm work in the study areas is described in the next section. In section three, Gini-decomposition technique is described and a conceptual framework is briefly discussed in section four. The impact of off-farm income on overall household income inequality is presented in section five. The paper ends with some concluding remarks.

2. THE NATURE OF OFF-FARM EMPLOYMENT

A questionnaire based survey was conducted in *Enderta* and *Adigudom* Districts (Woreda) southern Tigray, to analyze farm and off-farm employment in the region. The survey covered 201 heads of 'farm households' chosen randomly from a stratified sample area. The survey data include detailed information on the allocation of labor (for home, farm and off-farm activities), income sources, the purchase of farm outputs and inputs (including hired labor), the sale of farm outputs, consumption expenditure, credit and household compositions. The data were collected for the years 1996 and 1997[1].

Off-farm activities in which farm households participate can be categorized into wage employment and self-employment. Three types of wage employment can be distinguished, namely paid development work, manual non-farm work, and skilled

[1] The questionnaire is available at the web site: www.sls.wau.nl/twoldehanna/. See also Woldehanna (2000, p. 28-37) for detail description of the data.

(non-manual) non-farm work. Paid development work consists of jobs in community micro dam construction, community soil and water conservation activities such as construction of terraces and afforestation, and other community activities undertaken under the food for work program. Manual non-farm work is an activity in which farm households work for private and public construction companies in and around urban areas. Skilled (non-manual) non-farm work involves masonry, carpentry, cementing and related activities in public and private construction sites. Off-farm self-employment comprises mainly petty trade, transporting goods using pack animals, stone mining, pottery and handicraft, selling of wood and charcoal, local drinks making and selling of fruits.

Employment in paid development work does not require experience, skill and initial capital investment. Its wage rate is the lowest of all types of wage employment. If there are not enough jobs in paid development work, priority is given to poorer farm households. Manual non-farm work requires up to 40 Birr[2] in initial capital for the purchase of equipment. Although experience and skill are not required, farm households may spend a lot of time searching for a job in manual non-farm work. Usually, friendship and kinship play a dominant role in getting employment in this type of work. Skilled non-farm work definitely requires experience, skill and initial investment in equipment. To get involved in skilled non-farm work, farmers require at least 150-300 Birr initial investment. The wage rate for this type of activity is three times higher than that paid for manual work and those who have their own equipment are given priority in the local labor market. In off-farm self-employment, farm households need to have some amount of money as working capital to start the business (such as petty trade, handicraft and transport in goods using pack animals).
Although public intervention in the provision of skill and capital was limited, two local non-governmental organizations (NGOs) called Tigray Development Association (TDA) and Relief Society of Tigray (REST) were involved in the promotion of off-farm activities in the Tigray Region. TDA was providing training to farmers in masonry, carpentry and handicrafts. REST was involved in providing training and startup capital, on credit, for various off-farm activities. Currently, REST is no more involved in the provision of credit. Credit is rather being provided to farmers by a microfinance institute called Dedebit Credit and Saving Institution (DECSI).

[2] One US Dollar was equivalent on seven Ethiopian Birr during the survey period.

The average return to family labor from farm and off-farm activities is given in Table 1. Off-farm self-employment has the highest return among all the activities carried out by farm households. The average return to family labor on the farm (1.34 Birr/hour) or the marginal product of family labor on the farm (1.36 Birr/hour)[3] is lower than the return to labor in off-farm self-employment (2.96 Birr/hour), but higher than the return to labor in off-farm wage employment (0.72Birr/hour). It is also higher than the wage rate paid for hired farm labor (1.08 Birr/hour). The structure of the wage rate looks different when off-farm employment is decomposed into specific categories. The return to labor in paid development work (0.45 Birr/hour) is the lowest among all the activities. The return to labor in manual non-farm work (0.89 Birr/hour) is lower than the payment to family labor on the farm and the wage rate for hired farm labor. However, skilled non-farm wage employment has a return (2.8 Birr/hour) higher than the return to family labor on the farm and the wage rate for hired farm labor. It has a return close to that of off-farm self-employment. In general, the return to labor seems to be higher in *Enderta* than in *Adigudom*, although the marginal product of labor is almost equal in both districts. Non-farm wage employment is mainly available in the *Enderta* District. No skilled non-farm activity was observed and only one household was found to be involved in manual non-farm work in the sample drawn from *Adigudom* district.

There was rationing in the off-farm labor market in the sample area. When farmers are asked why they do not work more in off-farm activities, about 66 % of them responded that they could not obtain off-farm employment in and around their district (Table 2). This shows that agriculture is unable to absorb the available labor and there is potentially rationing in the off-farm labor market.

[3] The marginal physical product of family labour is derived from a Cobb-Douglass production function. The estimated Cobb-Douglas production function used is linearly homogenous and it produces a reasonable estimate of marginal productivity of family farm labor. It has an advantage of being easily interpreted. However, it is more restrictive than a translog production function (Lau 1986). If the coefficients of the translog function on the interaction terms are jointly significant, use of Cobb-Douglas function may represent mis-specification. In our case, in addition to the problem of multicollinearity, the estimated elasticity of family labor on the farm (and the shadow price of family farm labor) turned out to be negative for more than half of the households (53%) when the translog production function is used. The detailed specification and estimated results of the Cobb-Douglas production is given in Woldehanna, 2000.

Table 1: Average (median) farm and off-farm return to family labor (Birr‡/hour) by districts

Activity	Enderta	Adigudom‡‡	Total average
Average product of family labor on the farm*	2.76	2.56	2.73
Return to family labor on the farm**	1.50	1.26	1.34
Marginal product of family labor***	1.36	1.37	1.36
Wage rate paid for hired farm work	1.11	1.04	1.08
Wage rate for wage employment	0.89	0.55	0.72
Wage rate for food for work	0.62	0.55	0.45
Wage rate for manual non-farm wage work	0.90	0.85	0.89
Wage rate for skilled non-farm work	2.8	-	2.8
Return from off-farm self-employment	3.66	1.52	2.96

** The average product of family labor is calculated as the total value of farm output divided by the hours of family labor used on the farm;*

*** The average return of farm labor is computed as crop income minus variable inputs and one year depreciation of farm equipment and livestock wealth divided by the family labor hours used on the farm;*

**** The marginal product of family labor is calculated from a Cobb-Douglas production function.*

‡ One US Dollar is equivalent to seven Ethiopian Birr.

‡‡ No one participated in skilled non-farm work in Adigudom District.

Table 2: Reasons for not working more on off-farm employment

Reasons	% responding
No employment opportunity near by	66.4
Labor is needed on-farm	45.5
Wages too low for the kind of work	19.6
Just do not want to work off-farm	29.1

It is does not add up to 100 because the respondents were allowed to choose more than one answer.

Source: Own computation.

Table 3 shows the distribution of various income sources by income quintile. While the share of income from crop production and food for work employment declines as one moves to the higher income quintile, the share of income received from non-farm skilled wages work and non-farm self employment increases with the income quintile. The share of income from non-farm unskilled wage work increases with income, up to the fourth income quintile and declines thereafter, implying that there is a U-shaped relationship between income and the share of non-farm unskilled wage income.

Table 3 also shows that food for work is the most important supplementary income for the poorest households, while the role of incomes from non-farm self-employment and skilled non-farm work is extremely small, implying that poor household do not have the capacity to generate income from activities that require capital and skill.

Table 3: Share of income sources in total income by income quintile

Income sources	Income quintile				
	1st	2nd	3rd	4th	5th
Wage employment	28.7	26.5	32.1	28.1	24.8
Non-farm self employment	2.9	3.3	6.9	9.1	11.8
Non labor income	2.5	0.8	3.4	4.1	8.9
Crop income	54.5	45.4	43.7	39.2	41.2
Livestock income	11.4	23.9	14	19.5	13.3
Food for work income	24.7	18.4	21.2	13.4	9.3
Unskilled non-farm labor work	3.9	7.5	8.6	13.6	8.8
Skilled non-farm labor work	0	0	2.1	2.1	7

Source: Own computation

3. CONCEPTUAL FRAMEWORK

In a farm household economy with a perfect market, labor is allocated between farm and off-farm activities in such a way that the reservation wage rate equals the wage rate for off-farm activities (Becker 1965; Gronau 1973; Huffman and Lange 1989). This means that individuals are willing to participate in off-farm work as long as their marginal value of farm labor (or reservation wage) is less than the off-farm wage rate they command. This implies that poorer farm households have a stronger incentive to diversify their income sources into off-farm activities because they have a lower marginal value of farm labor. The other motive to diversify income sources into off-farm activities is to manage the risk associated with agricultural production. The extent of the motive to take risk to diversify income depends critically on risk aversion. Because risk aversion varies inversely with wealth (Newbery and Stiglitz 1981), the incentive to take risk to diversify income sources is stronger for poor than for rich if off-farm income is negatively related with farm income.

However, there can be entry barriers in the off-farm labor market because off-farm activities may require investment for equipment purchase or rent, skill acquisition and license fees. If households face binding liquidity and credit constraints, poor households cannot afford the investment required in the off-farm labor market.

Hence, if there are entry barriers in the off-farm labor market, the capacity to diversify income sources into off-farm activities is lower for poorer farm households. Individual assets and wealth can affect the type of non-farm activities a farmer picks up and can worsen the income distribution (Reardon and Taylor 1996). As a result less wealthy farmers spend most of their time in low paying off-farm activities for which the entry barrier is low. If agriculture is risky (and households are risk averse), a household will choose an occupation that is negatively correlated with agricultural income (Newbery and Stiglitz 1981).

If a farmer faces liquidity (or credit) and skill constraints, he will prefer the one that requires less initial capital and less skill. A farmer with better assets faces relatively less liquidity (credit) constraints and may be able to work in off-farm activities that require some skill and initial capital such as trading, carpentry and masonry. Therefore, off-farm activities that require skill and initial capital worsen the income distribution if there is liquidity and borrowing constraint.

If off-farm activities are risky and are positively related with farm income, richer farm households have more incentive and ability to diversify their income sources into off-farm activities than poorer households because of the fact that richer households are less risk averse.

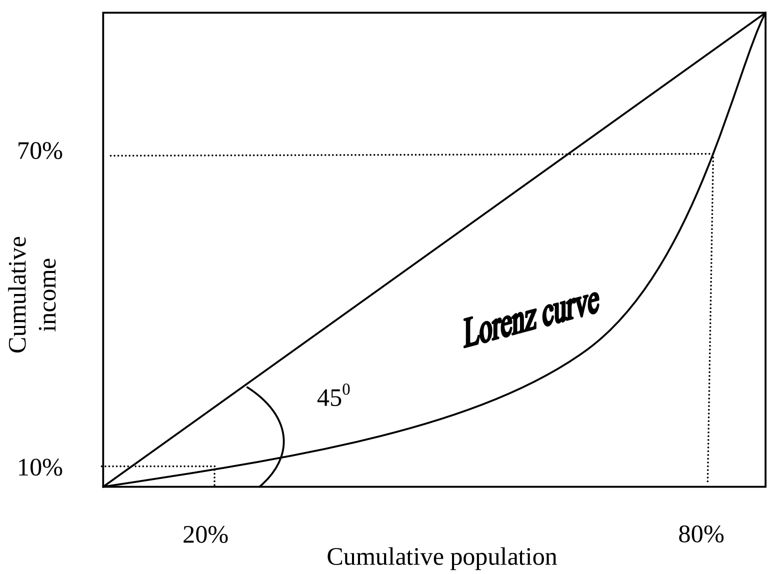
Given the egalitarian type of land distribution, farm income is not expected to be the source of income inequality in rural areas.

In order to reduce inequality in the society, it is important to examine inequality among individuals not households. The total inequality calculated will be underestimated if household instead of individual data are used (Haddad and Kanbur 1990). Researchers, however, use household level data because it is difficult to generate data at individual level.

4. GINI COEFFICIENT AND GINI DECOMPOSITION TECHNIQUE

Gini decomposition is used to analyze the contribution of alternative income sources to overall income inequality (Lerman and Yotzhaki 1985; Reardon and Taylor 1996). A *Gini coefficient* is a number that summarizes inequality among individuals. It is the ratio of the area between the *Lorenz curve* and the 45^0 line of perfect equality to the area of the triangle below the 45^0 line (Figure 1). It satisfies the four principles of inequality measurement (Ray 1998, p. 174-178): anonymity, population, relative income and Dalton's transfer principles. A Gini index has the advantage of being decomposed into various sub-groups and the marginal effects of each subgroup to the over all *Gini index* can be computed. It is also possible to compute A Gini index from a magnitude that can be negative.

Figure 1: Lorenz curve of an income distribution



Algebraically, a Gini coefficient (*G*) can be calculated from an individual income (record data) using the following formula (Lerman and Yotzhaki 1985)

$$G = \frac{2 \, cov \, [Y, F(Y)]}{\bar{Y}} \qquad \textbf{(1)}$$

where *cov[Y, F(Y)]* is the covariance of total income with its cumulative distribution of income (*F(Y)*), *Y* is total household income, and $\bar{Y}$ is mean household income.

Household total income can be decomposed into K sources (y_k). Assuming that the various income sources are not correlated to each other, the overall Gini coefficient can be rewritten as

$$G = 2\frac{\sum_{k=1}^{K} cov\,[\,y_k\,, F(Y\,)]}{\bar{Y}} \qquad \textbf{(2)}$$

Then dividing and multiplying each component k by $cov(y_k, F_k)$ and the mean income of source k ($\bar{y}_k$) yields Gini decomposition by income source as

$$G = \sum_{k=1}^{K} \frac{\text{cov}\,[y_k\,, F(Y)]}{\text{cov}(y_k\,, F_k)} \times 2\frac{\text{cov}\,(y_k\,, F_k)}{\bar{y}_k} \times \frac{\bar{y}_k}{\bar{Y}} = \sum_{k=1}^{K} R_k\; G_k\; S_k \qquad \textbf{(3)}$$

where F_k is the cumulative distribution of income from source k, R_k is the Gini correlation between income from source k and total household income, G_k is the relative Gini of income from source k, S_k is the income from source k's share of total household income.

The over all Gini coefficient (G) is, therefore, obtained as the sum of production of Gini correlation (R_k), the relative Gini of income sources (G_k) and the share of the income sources in total income (S_k). The relative contribution of each income from source k to the over all Gini index is obtained by dividing the products of R_k, G_k, and S_k by the over all Gini. That is, the relative contribution of income from source k to the income inequality (Gini index) is given by: $\frac{\mathrm{S_k} * R_k * G_k}{\mathrm{G}}$.

To analyze how changes in particular income sources affect overall income inequality, consider a change in each household's income from source k equal to $e_k y_k$ where e_k is close to one. The partial derivative of the overall Gini (G) with respect to a percentage change (e) in income source k is given by (Lerman and Yotzhaki, 1985, p. 152):

$$\frac{\partial G}{\partial e_k} = S_k (R_k G_k - G) \qquad \textbf{(4)}$$

Then dividing (4) by G, the relative effect of a marginal change in source *k's* income on the Gini for total income is given by

$$\frac{\partial G}{\partial e_k} \frac{1}{G} = S_k (R_k G_k - G) \frac{1}{G} = \frac{S_k R_k G_k}{G} - S_k . \qquad \textbf{(5)}$$

This is equal to the relative contribution of income from source *k* to the overall income inequality minus the share of income from source *k* in total income.

5. INCOME INEQUALITY AND INCOME SOURCES

In this section, Gini coefficients for the total household (1) and various farm and non-farm incomes (3) are calculated. Total household income is decomposed into livestock income, crop income, off-farm wage employment income, off-farm self-employment income and non-labor income. Income from off-farm wage employment is further decomposed into income from paid development work (food for work), income from non-farm manual work, and income from skilled (non-manual) non-farm work. Then the income sources elasticity of the overall Gini index is computed using equation (5).

Gini coefficients for total income as well as the share of income from various sources and their marginal contribution to overall Gini coefficients are presented in Tables 4 and 5 respectively. Except for income from livestock, there is no change in the order of Gini coefficients and their marginal contribution when they are calculated from incomes stated at household level and in per capita terms. Crop income has the highest contribution to overall income inequality (as measured by relative Gini coefficients, 0.42) followed by wage employment (0.26) and livestock income (0.14). When income is stated in per capita terms, the contributions of crop, wage employment and livestock are 0.44, 0.27, and 0.17, respectively. The effects of crop and off-farm wage incomes on the income inequality among households are negative implying that when crop income and wage employment increase, the income that will be earned by the people in the lower income bracket will be higher than that earned by those in the higher income bracket. The fact that cropping (which is land intensive) reduces income inequality reflects that owning land leads to egaliterianism. The results are mixed when wage income is decomposed into various categories. Paid food for work program is the only type of off-farm wage income that reduces income inequality. It is unequally distributed by itself (with a Gini index of 0.66), but favors the poor. The elasticity of total income inequality with respect to food for work income is the highest of all the other elasticities of income sources.

Table 4: Gini Decomposition by income sources (income stated at household level)

Household Income components	Mean	S_k	R_k	G_k	G_k*R_k	$S_k*R_k*G_k$	$(S_k*R_k*G_k)/G$	$(S_k*R_k*G_k)/G-S_k$
Off-farm self-employ income	262.50	0.068	0.598	0.836	0.500	0.034	0.103	0.035
Off-farm wage income	858.75	0.280	0.489	0.628	0.308	0.086	0.261	-0.019
Income from food for work	437.89	0.174	0.183	0.664	0.122	0.021	0.064	-0.110
Manual non-farm wag income	284.58	0.085	0.406	0.883	0.358	0.030	0.092	0.007
Skilled non-farm wage income	136.28	0.022	0.794	0.978	0.777	0.017	0.053	0.031
Non-labor income	194.31	0.039	0.707	0.951	0.672	0.026	0.080	0.041
Net farm crop income	1339.65	0.448	0.698	0.442	0.308	0.138	0.419	-0.029
Livestock income	497.40	0.164	0.425	0.643	0.273	0.045	0.136	-0.028
Total household income	3152.60					0.330		

S_k is the average share of income from source k in total income; G_k is Gini index of inequality for income from source k; R_k is Gini correlation with total income ranking; G is the Gini index of total income inequality; $\frac{S_k * R_k * G_k}{G}$ is the relative contribution of income from source k to the Gini index of total income inequality; $\frac{S_k * R_k * G_k}{G} - S_k$ is the elasticity of the Gini index of inequality with respect to income source k.

The effect of income from livestock on income inequality is negative when income is calculated in per capita terms, but positive when it is stated at household level. The results in Table 5 (stated in per capita income terms) give more sense given that livestock activities require capital and labor which poor farmers and female headed households (labor poor) can not afford.

Non-farm wage and self-employment incomes have a non-equalizing effect. Income from unskilled (manual) and skilled (non-manual) non-farm work increases overall income inequality. Non-labor income (such as gifts, remittances, and property rent) also increases income inequality. The marginal effect on income inequality is higher for non-labor income than for non-farm wage and self-employment income.

Table 5. Gini Decomposition of per capita household income sources

Per capita household income components	Mean	S_k	R_k	G_k	G_k*R_k	S_k*R_k*G_k	(S_k*R_k*G_k)/G	(S_k*R_k*G_k)/G-S_k
Off-farm self-employ income	77.55	0.068	0.608	0.853	0.518	0.035	0.107	0.039
Off-farm wage income	243.59	0.280	0.499	0.633	0.316	0.089	0.268	-0.012
Income from food for work	130.81	0.175	0.303	0.696	0.211	0.037	0.112	-0.063
Manual non-farm wag income	90.16	0.083	0.499	0.899	0.449	0.037	0.112	0.030
Skilled non-farm wage income	22.63	0.022	0.401	0.977	0.392	0.009	0.027	0.004
Non-labor income	65.57	0.039	0.733	0.960	0.704	0.028	0.084	0.044
Net farm crop income	391.38	0.448	0.712	0.453	0.323	0.145	0.438	-0.011
Livestock income	153.19	0.164	0.553	0.683	0.378	0.062	0.188	0.023
Total household income	931.28	1.000				0.330	1.000	

S_k is the average share of per capita income from source k in total per capita household income;
G_k is Gini index of inequality for per capita income from source k;
R_k is Gini correlation with total per capita household income ranking;
G is the Gini index of total per capita income inequality;

$\frac{S_k * R_k * G_k}{G}$ *is the relative contribution of income from source k to the Gini index of total per capita income inequality;*

$\frac{S_k * R_k * G_k}{G} - S_k$ *is the elasticity of the Gini index of per capita income inequality with respect to income source k.*

In principle, inequality has to be calculated from individual instead of household data. However, obtaining individual data and intra household resource allocation is problematic. Thus, in many surveys, income data is collection at household level data. For this paper, the survey data available are at household level and as a result the actual income inequality will be higher than what is presented (Haddad and Kanbur 1990). Hence the estimated inequality figures in this paper must be interpreted cautiously.

Findings from previous studies regarding the impact of off-farm income on rural income inequality appears to be very diverse. Making a comparison of the various results is not easy either, as most empirical studies do not use the same type of income definition as well as income decomposition and methodology. In Palanpur (India), Lanjouw and Stern (1993) found that off-farm income in general increased income inequality in 1983/84 and reduced it in 1981/82. Stark, Taylor and Yitzhaki (1986) found that remittance from domestic and international sources had both positive and negative effects on income inequality in two villages of Mexico. In rural Pakistan, Adams (1994) found that non-farm income makes a small contribution to income inequality despite its large share in total income. Non-farm income also has a low Gini coefficient and is poorly correlated with total income. When non-farm income is decomposed into different categories, income from government employment and off-farm self-employment is found to increase income inequality while income from unskilled labor reduces it. In the Philippines, Leones and Feldman (1998) found that while income from remittance, trading and skilled labor increases inequality, income from agricultural wage labor and gathering activities such as fishing and logging reduces inequality. All these studies appear to have one thing in common. Income sources that need skill and capital to enter (such as non-farm self-employment and income from skilled wage labor) increase income inequality.

The fudings of this study also confirm this. Off-farm activities that have entry barriers and require capital to start have a positive impact on income inequality. It is only income from food for work programs that has a negative effect on rural income inequality. This is because the food for work jobs not need skill and capital and are initially targeted to provide employment for poorer farm households. However, there is a peculiar finding in this study which indicates that unskilled non-farm wage work increases income inequality. One possible explanation for this is that unskilled non-farm wage work does not require education and skill, but it involves a high transaction cost (such as search and commuting cost) which poor farmers cannot afford. The survey from which the data is obtained indicates that farmers need to have their own equipment (worth at least 40 Birr) and should be able to commute to towns in order to get jobs in the unskilled non-farm labor market (Woldehanna and Oskam, 2001).

The fact that there is an entry barrier for the poor is a possible reason for non-farm income to have a dis-equalizing effect from an investment perspective (Reardon, Crawford and Kelly, 1994). Skilled non-farm wage employment and off-farm self-employment require skill and capital to start. In the absence of a perfect credit market, it is only the rich households that can afford to enter into self-employment. Even in the unskilled non-farm labor market, the transaction cost of looking for jobs in nearby urban areas, coupled with the existence rationing in the labor market, provides an advantage to richer farm households.

We can also explain the dis-equalizing effects of non-farm income from the perspective of risk-taking behavior of farmers. Some of the non-farm activities such as trading may be risky and are positively correlated with farm income. Because of the consumption linkages, there will be more trading and non-farm business in rural areas when there is a good harvest. Hence, given the fact that off-farm business activities are risky and since a positive relationship exists between off-farm business income and farm income, it is only less risk averse farmers (richer) who have the incentive and the capacity to undertake off-farm self-employment activities.

As a result, income from the non-farm labor market increases income inequality. This implies that unless rural non-farm activities are promoted targeting particularly the poor, wealthy farm households will dominate the most lucrative form of non-farm activities such as masonry, carpentry and trading.

6. CONCLUSIONS

Rural Poverty can be reduced by increasing income and/or reducing income inequality because poverty is a function of both income and inequality in income. Even if income in rural areas increases, poverty can still increase if the additional income goes to the richer households only. If there are entry barriers in the labor markets, off-farm employment may not reduce income inequality among farm households in rural areas. Since increasing off-farm employment in rural areas is one of the policy instruments for reducing poverty in Ethiopia (MoFED 2002), it is crucial to examine the effect of increasing rural non-farm income on income inequality.

This study found that off-farm income is one of the sources of income inequality among farm households in the rural areas because of wealthy farmers dominate the most lucrative and risky non-farm activity such as masonry, carpentry and trading. Since the present public work program favors the poor it reduces the income inequality that exists in the rural areas.

Poverty does not only depend on economic growth but also on the distribution of income. If off-farm employment becomes the main source of income inequality in rural areas, its role in the alleviation of poverty will be very limited. Therefore, some policy reform is required to manage the redistribution effect of expanding economic activities into off-farm employment.

A number of measures can be taken in order to reduce the income inequality effect of non-farm activities so that off-farm employment will have a strong impact on poverty. First, rural non-farm investment programs need to focus on non-farm activities in which the poor would participate more than the rich. Second, the underlying elements that hinder the participation of farm households in non-farm activities must be addressed and removed. Measures such as the establishment of training centers to tackle skill barriers, the provision of credit for the poor together with business-extension advice and the expansion of public employment schemes could be taken towards this end. Provision of information to increase public awareness about the labour market could also be helpful reduce the transaction cost of searching for non-farm jobs. Improving rural infrastructure can also reduce spatial income inequality by increasing farmers' income earning opportunities. These recommendations can fit quite well to the activities of TDA, REST and DESCI, which are involved in providing training, and credit to farmers in non-farm activities in the region.

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DOES TYPE OF TENURE IMPACT ON TECHNICAL EFFICIENCY OF FARMERS? (A COMPARATIVE ANALYSIS OF OWNER-OPERATORS AND "TENANTS")*

Worku Gebeyehu**

Abstract

This study tries to examine the technical efficiency of farmers and investigate its variation between owner-operators and tenants. A Cobb-Douglas stochastic frontier production function and other econometric tools are employed on a cross-section data of 340 households. Mean technical efficiency of sample households is found to be around 62.8 percent, revealing a considerable potential for output gains under the given technology. Farmers having less than two hectares of land and "literate individual" headed households reported higher efficiency. Wealth, credit, fertilizer and rainfall contributed significantly to increase production. Regardless of tenancy-associated problems, no significant efficiency gap is observed between owner-operators and tenants. Although, it requires further inquiry to have a strong position, encouraging land rent/lease among farmers holding an incompatible resource mix could enhance efficiency. Findings suggested that efforts should be exerted towards providing training and extension services, developing small-scale irrigation schemes and expanding the coverage of credit provision to improve productive use of resources of farmers operating in both tenure systems.

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** Researcher, Ethiopian Economic Association/Ethiopian Economic Policy Research Institute (EEA/EEPRI).

1. INTRODUCTION

Land is a state property, yet it is not accessible to every one. In particular, recently married young people, demobilized soldiers returnees from resettlement areas and similar groups usually suffer from lack of access to land (Dessalegn 1994). On the other hand, some landowners lack indispensable inputs such as oxen, and male labour due to illness, old age, death, or complete absence of male family heads. As many as 30% of all households in the country had no oxen at all and only 8% of farm households had more than one pair of oxen in 1974 (Daniel, et al. 1997). A study on some parts of the Ethiopian highlands indicated that 14% of sample households were female headed, 21.1% had no oxen and 31.4 % had only one ox (Wendwosen 1998). In one study, it was found that women headed as much as 25% of households and almost all of them were either widowed or divorced (Dessalegn 1994). Landless and farmers with insufficient land and landholders with inadequate complementary inputs to complement each other and make use of their inputs the usual way of using idle resource is through tenancy arrangement. For instance, in Mafud district of North Shewa, of the total households who gave land to tenants, 47% did not have a male worker; another 40% had only one worker. Around 65% were without oxen (Ege 1994).

Whether mode of land use could affect the level of efficiency of farmers has been an issue of discussion for many years. In particular, there are opposing views about the impact of tenancy on the use of inputs. Some argue that tenants lack security to invest on assets and conserve the land on the belief that the fruits from such investments are likely to be harvested only in the long run. Tenants might also lack the incentive to maximise output since landowners claim part of the produce. Others argue that tenancy is a mechanism of economically utilizing resources, which are disproportionately available in the hands of different individuals and kept idle otherwise.

The validity of one of the two divergent views could only be confirmed through empirical findings. Given that the issue of land use arrangement and its impact on efficiency is a very sensitive economic and political concern and the empirical findings on Ethiopia are very sparse conducting a study on this area has a paramount importance. The objective of this study is, therefore, to examine factors affecting production levels of farmers and efficiency differentials between own operators and tenants in the case of Ethiopia.

The source of data for this study is the first round Ethiopian Rural Household Survey conducted in 1994/5. The Survey was run by the Department of Economics, Addis Ababa University in collaboration with the Centre for the Study of African Economies, Oxford University (CSAE) and the International Food Policy Research Institute (IFPRI). The study employs descriptive statistics, Maximum Likelihood econometric technique to estimate a stochastic frontier production function and other tests.

Providing empirical evidences on technical efficiency of farmers and assessing factors, including land use arrangements, contributing towards the productive use of resources might help policy makers to invigorate their conceptions of farmers' behaviour and operation in practice and accordingly revitalize their actions. Several studies assessed the efficiency of farmers in Ethiopia, yet no attempt was made to examine efficiency differential of farmers operating into two different land use arrangements as comprehensively as this study does. Gavian and Ehui (1996) and Ahmed et al. (2002) conducted similar studies, yet the focus was only on one of zone in Oromiya region, Arsi. Covering a wider geographical area and addressing the issue in its peculiar way, this study will contribute its share towards building the literature on the subject.

However, the study has its own limitations, in particular with respect to definitions of owner-operators and tenants. The Ethiopian Rural Household Survey does not include those who are absolutely denied of having state land. Nevertheless, it identifies types of farmers; those operating on their own land and those who rented in land in addition to their own small plots. Even in this respect, the survey only provides the size of rented-in land and own land and fails to segregate the input and output magnitudes into two types of land tenure. Thus makes it difficult to make plot level analysis as Gavian and Ehui (1996) did. The average land area for own operators considered in the sample was about 1.93 hectares. On the other hand, those who have their own small plots but acquired a greater percentage from other farmers through rent were operating on about 1.81 hectares. The average share of rented-in land constituted about 60% of the total cultivated land during that particular period. Thus, this paper defines owner-operators as those who work only on their own holdings and "tenants" are those farmers that have their own plots, but the land they rented constitutes more than 50% what is under cultivation during the study period.

2. SURVEY OF LITERATURE

2.1 Theoretical Literature

Volumes of theoretical controversies and empirical evidences are documented in the literature on the impact of land use arrangements on efficiency of farmers. Some scholars argue that tenancy and associated institutional factors impinge on the efficiency of agricultural resources that are utilized, whereas others consider tenancy as a way of utilizing resources in the hands of different parties in a more optimal way.

Some of the major underpinning justifications for considering tenancy as an inefficient institution include the following. A tenant "... will not make long-term investments in his holding unless he is secure in his expectation of reaping the benefits of his investments " (Bruce 1986, p. 28). Owing to a high rate of discount (r) resulting from uncertainties on future benefits, tenants usually tend to invest on marketable assets and/or goods having shorter gestation instead of permanent improvements (Barrows 1973 and Junakar 1976). Tenants also undersupply their variable inputs because of the disincentive effect associated with rental payment. In relation to this, Marshall (1920) argued that tenancy (sharecropping in particular) is an inefficient system and productivity is an inverse function of the rental share. He, therefore, stresses that some sort of government intervention is required either to reduce rent or prohibit this form of arrangement totally in order to safeguard social welfare (Bell 1977). Taslim (1988) argued that landowners interlocked land lease markets with other input markets to extract maximum surplus from their tenants and keep them in perpetual bondage of indebtedness. The inter locking prohibits the liberty of tenants from acquiring inputs from cheaper areas. Other obligations imposed by landowners also share the productive time of tenants and reduce their efficiency. Thus, own-operators and tenants either lie on different production functions or the latter operate less efficiently than otherwise.

Other scholars try to backup their positions with the argument that if the landowner does not own some types of assets, especially types with imperfect or expensively accessed markets (for instance draught power) his net yield from combining labour with other assets may substantially decrease and inspires him to rent out his land. Lipton (1985) argued that "… if a person does not own some types of assets, especially types with imperfect or expensively-accessed markets, that person's net yield from combining his labour with other assts may be substantially reduced. … Lack of owned oxen, in conjunction with imperfect markets in draught-power, may so reduce the return to own-operated farmland as to induce the land owner to rent out". Toutique, (1988) also noted that tenants might own inputs such as knowledge or husbandry skills, land, oxen and finance for which the market is either imperfect or non-existent. Landless and farmers with insufficient land may be forced to consider the opportunity cost of leaving their resources idle and become a wage labourer, with the amount that they are supposed to pay for the land owner if they choose to be a tenant. It is usually the case that cooperation between tenants and landholders benefit both parties than otherwise.

In cases of problems associated with tenancy operation, the landowner could induce efficiency by supervising the application of the desired level of inputs and efforts (Cheung 1969). Another alternative for the landowner is to hire a wage worker. A wage labourer requires intensive supervision by an experienced family member of the land owner who would work with and induce the hired worker to put his maximum effort on the field. Such intensive supervision might not be required for a tenant. A tenant may be less efficient but knows that the effect of his inefficiency would affect his share. There rarely exists the possibility of attaching wage rates with the amount of production and thus, there will be no incentive for a wage labourer to exert his utmost effort. Even if it is possible to supervise a hired labourer effectiveness, easy access to wage labour may not be simple in rain-fed subsistence farming where every farmer could be busy simultaneously.

The insecurity argument against tenancy may not have a strong case in Ethiopia. Ethiopia where the reallocation of land by the government for the benefit of increasing the number of claimants makes 'landholders' themselves insecure. The institutional environment is such that it fails to allow both land owners and tenants to have a vision for long term investment on the land. Hence, no tangible evidence exists that insecurity makes tenancy inferior to ownership on grounds of efficiency. As Lipton (1985) argued, rather tenancy is a means of adjusting different ownership holding sizes towards an operationally optimum land size and utilizing other resources that could have been left idle. This allows operation near to the bottom of the average cost curve, implying maximizing output at given level of inputs. The existence of interlocked markets further facilitates optimal operation. It helps to facilitate the provision of cheap credits in the presence of costly monitoring and moral hazard problems in less developed countries, and tie up land, credit and labour markets to avail inputs at the right time, quantity and quality. While the different arguments have their own rationale and reflect realities on the ground, their validity is confirmed through empirical evidence.

2.2 Empirical Evidence

Like the diverse theoretical views, the empirical findings on the impact of tenure arrangement on efficiency of farmers are mixed. Jabbar (1977) conducted a study on one hundred farmers from three districts of Bangladesh and found owner-operators to be more efficient. He implied from the result that the pattern of resource ownership and property relations was improper for efficient operation of tenancy. Similarly, Ahmed et al. (2002) cameout with a result from their stochastic frontier production function that land transactions such as sharecropping and land gift that restrict tenants' decision making are technically inefficient compared with owner-cultivated or fixed rental tenures.

Junakar (1976) study on Indian agriculture showed that owners were more productive than tenants for large farms, but no significant difference was observed between small farmers.

Based on his review of various empirical works, Lipton (1985) concluded that owner-occupiers within a given village could neither be much more nor much less efficient than tenants (in particular sharecroppers). Huang (1975) also noted yields of tenants to be at least as good as owner operators if not better in a number of countries as it was found by himself in Malaysia, Ras and Malone (1965) in India, Ruttan (1966) in the Philippines, Bray (1963) in the US, Cheung (1968) in China and Hendry (1960) in Vietnam. He further demonstrated that tenants and owner-tenants (those who own and rent land) reported notably higher yields than owner cultivators in particular in the case of Malaysia. Contrary to fears of under supplying inputs, while only 36 % of owner cultivators used fertilisers, 57% of tenants and 69% owner tenants used this input. Hossain (1977) undertook another study on three different areas of Bangladesh and revealed that land productivity was higher for tenants than owner operators.

Studies dealing with the economic impacts of tenancy in Ethiopia are inadequate. Bereket and Croppenstedt (1995) observed an indication that landowners and tenants (specifically sharecroppers) operate in the tenancy market to adjust land holdings to factor endowments such as family size and number of oxen and concluded that “if off - farm employment opportunities are limited, sharecropping helps increase efficiency".

Gavian and Ehui (1996) tried to test the relative efficiency of three different informal and "less" secure land contracts (fixed rent, sharecropping and borrowed) on data collected from 477 plots in Arsi Zone. Although informally contracted farmers applied inputs more intensively, the land was cultivated 7% to 16% less efficiently compared to own-operated farms. They attributed the result to the widespread insecurity of land and suggested a need for more stable and enforceable leases. Insecurity of tenure has its impact on long term investments on areas like land conservation or soil protection whose effect could only be examined through comparing different landholding arrangements over a long period. Thus, it may be unjustifiable to conclusively attribute inefficiency of tenant farmers to insecurity on the basis of a one year cross section data.

3. SPECIFICATION OF MODELS AND DEFINITION OF VARIABLES

3.1 Stochastic Frontier Production Function

There are various ways of measuring efficiency of farmers. Investigating the validity of the position that tenants under supply efforts with a given level of inputs requires a methodology that reveals the extent to which a tenant or for that matter an own-operator deviates from the most efficient way of producing. In this respect, technical efficiency measures the percentage by which the level of production of a tenant or own-operator is less than the frontier (most efficient) level of output.

Aigner and Chu (1968) and later Afriate and Richmond (1974) specified a deterministic frontier to estimate technical efficiency. The model assumes that the amount of output that farmers/firms produce with a given level of resources varies only due to differences in the level of efforts that they exert on optimally utilizing their factor inputs and the influences of external factors which are invariables across farmers/firms. Let the (estimated) frontier and actual level of output be given by equations (1) and (2) as

$$Y^* = F(X_i, \beta) \quad \textbf{(1)}$$

$$Y = F(X_i, \beta) \exp(-\mu_i) \quad \textbf{(2)}$$

where X_i and β are matrices of factors of production and their respective coefficients, and μ_i is an error in operation committed by the farm or firm. Thus, technical efficiency of a farmer, for instance, could be represented as

$$TE_i = Y/Y^* = F(X_i, \beta) \exp(-\mu_i) / F(X_i, \beta) = \exp(-\mu_i) \quad \textbf{(3)}$$

A farmer is technically efficient if and only if his actual output given the level of inputs is equal to the predicted level of output. Otherwise, there will be a deviation from the frontier level of output by 1-TE_i. The inherent assumption of the deterministic model that farmers share similar technology, institutional setting, physical resource endowments, as well as environmental and weather conditions could not hold in the real world. Hence, it may not be practical to fully attribute mismanagement of resources as the only reason for failure to produce the predicted level of output. The stochastic frontier production function specification gives a room for the influences of external factors.

The stochastic frontier production function model assumes the common error term (ε) to be decomposed into two components and specified as:

$$Y = f(X_i, \beta)e^{v-u} \quad \textbf{(4)}$$

or

$$Y = F(X)\exp(v-u)$$

v_i are assumed to be independently and identically distributed as $N(0, \sigma_v^2)$ and the covariance between u_i and v_i to be zero. The maximum production limit (Y) is bounded above by a stochastic quantity $F(X_i; \beta)\exp(v_i)$. The non-negative error term u_i, in exp (-u_i), measure the degree of technical inefficiency, which are assumed to have a non-negative truncation of either half-normal, exponential or gamma distribution with mean and variance, $N(0, {\sigma_u}^2)$ (Battese 1992 p. 190).

Decomposition of the commonly observed error term (ε) into two components in case of estimation is not as simple as its specification. Aigner, Lovell and Schmidt (1977) brought about a procedure called ALS whereby they decomposed the error term into two components:

$$\varepsilon = u + v \quad \textbf{(5)}$$

where v follows the usual normal distribution with constant variance and zero mean: $N(o, \sigma_v^2)$ and *u* follows the truncated normal,

$$F(u) = \frac{2}{\sigma_u \sqrt{2\pi}} \exp\left[\frac{-u^2}{2\sigma_u^2}\right], u \geq 0 \quad \textbf{(6)}$$

(Fishe and Maddala 1994, p. 76). Furthermore, assuming *u* and *v* to be independently distributed,

$$F(\varepsilon) = \frac{2}{\sigma} \phi\left[\frac{\varepsilon}{\sigma}\right]\left[1 - \Phi(\frac{\varepsilon\lambda}{\sigma})\right] \quad \textbf{(7)}$$

where $\sigma^2 = \sigma_u^2 + \sigma_v^2$ **(8)**

$$\lambda = \frac{\sigma_u}{\sigma_v} \quad \textbf{(9)}$$

and $\phi(.)$ and $\Phi(.)$ are density and distribution functions of the standard normal, respectively (Fishe and Maddala 1994, p. 76). From equation 1 above, technical efficiency for each farm is given as:

$$e^{-u} = \frac{Y_i}{\left[f(X_{i,}\beta)e^{v_i}\right]} \quad \textbf{(10)}$$

λ in equation (9) indicates the relative influences of forces that are under the control of farmers and events external to them. A value above unity is an indication of the impact of internal factors on production to outweigh the respective effect of external factors.

Based on the works of Aigner, Lovell and Schmidt (1977), Assefa (1995) provided an estimation procedure in such a way that parameters of the frontier and density functions of the two error terms are estimated through maximising the log-likelihood function, which could be given as:

$$\ln L(Y/\beta,\lambda,\sigma^2) = N\ln\sqrt{\frac{2}{\pi}} + N\ln\frac{1}{\sigma} + \sum \ln\left[1 - F(\frac{\phi_i\lambda}{\sigma})\right] - \frac{\sigma^2}{2}\sum\phi_i^2 \qquad \textbf{(11)}$$

Since v_i are not observable, computing efficiency magnitudes for each farm using equation (10) is impossible. Jondrow et al. (1982) estimated farm level technical efficiency as:

$$E\left(u_i/\varepsilon_i\right) = \frac{\sigma_u\sigma_v}{\sigma}\left[\frac{\phi(\varepsilon_i\lambda/\sigma .)}{1-\Phi(\varepsilon_i\lambda/\sigma)} - \frac{\varepsilon_i\lambda}{\sigma}\right] \qquad \textbf{(12)}$$

where $\phi(.)$ and $\Phi(.)$ are standard normal density and distribution functions evaluated at $\frac{\varepsilon_i\lambda}{\sigma}$ and λ is estimated at $\lambda = \frac{\sigma_u}{\sigma_v}$ respectively. Replacing ϕ, σ, λ by their estimates in equation (12), one can drive values of u_i and v_i. Then, technical efficiency indices of individual farmers would be computed as

$$TE_i = \exp\left[-E(u_i/\varepsilon_i)\right] \qquad \textbf{(13)}$$

Following the rules of Ibid, (1982) and Battese and Coelli (1988), the average technical efficiency of all farmers in the sample is given by

$$E(e^{-u_i}) = 2\exp(\sigma_u^2/2)(1-\Phi^*(\sigma_u)) \qquad \textbf{(14)}$$

where Φ^* is the standard normal distribution function (Assefa, 1995).

3.2 Estimation Methods and Testing Procedures

3.2.1 Estimation Methods

Assuming a Cobb-Douglas specification to describe the underlying technology of smallholder agriculture, a stochastic frontier production function is estimated through the Maximum Likelihood Maximum Iteration Method using Limdep 7[1] econometric software. The estimated function is specified as:

$$Y_i = \alpha_0 + \sum \alpha_i X_{ij} + v_i + u_i \quad \textbf{(15)}$$

where,

Y_i = log of cereal outputs of households,

X_{ij} = Logarithm values of inputs and household specific attributes,

u_i = Technical efficiency parameter assumed non-positive values and a half-normal probability distribution,

v_i = the usual stochastic disturbance term which is normally distributed with $(0, \sigma_v^2)$.

Farm specific and average technical efficiency figures could be estimated using equation (12) and (14).

3.2.2 Econometric Tests

A. Chow Test

Assuming two independent production functions for owner-operators and tenants, the Chow test is specified as[2]

a) $\mu_{1i} \sim N(0, \sigma^2)$ **(16)**

$\mu_{2i} \sim N(0, \sigma^2)$

b) μ_{1i} and μ_{2i} are distributed independently.

[1] Limdep7 (1998) is an Econometrics software written by William H. Greene and Windows interface is made by M.J. Lowe.

[2] For further Discussion of the test please refer Gujarati (1988).

First, a single “pooled” regression, combining both own-operators (*N1)* and tenants *(N2*), is estimated to obtain residual sum of square (s1) with *N1+N2-K* degrees of freedom, where *K* is the total number of estimated parameters. The second step is to run two individual regressions for two groups of farmers and collect the respective residual sum of squares (s2 and s3) with degrees of freedom *N1-K*, and *N2-K*. Using the results for the respective parameters, F-test is applied.

$$F = \frac{[s_1 - (s_2 + s_3]/K}{(s_2 + s_3)/(N_1 + N_2 - 2K)} \quad \textbf{(17)}$$

with degrees of freedom *(DF) =K, N1+N2-2K*. If the computed F-exceeds the critical F-value, the hypothesis of considering two production functions as the same would be rejected.

B. Wald Test

Assuming a zero covariance between coefficients of production functions for the owner-operator and the tenant, a Wald test is applied to examine elasticity differences for each kind of key factors of production[3]. Under the null hypothesis of no difference, the Wald-test statistics is:

$$W = (\beta_i^{own} - \beta_i^{tent})^2 \big/ [Var(\beta_i^{own}) + Var(\beta_i^{tent}) \sim \chi^2_{(1)} \quad \textbf{(18)}$$

3.3 Definition of Variables

1. *Output (Y):* Households considered in the study harvested a variety of cereals. However, inputs used were not disaggregated into different types of outputs. In the absence of a clue for segregation of inputs, the only feasible way of comparing outputs with inputs is to aggregate the different cereals into one monetary unit. Production function being a description of functional relationship between physical outputs and corresponding physical inputs, expressing output in monetary terms has its own conceptual problems. Thus, monetary value of a variety of cereals including *teff*, (mixed black and red *teff*), barely, wheat, maize, sorghum and millet produced by sample farmers are aggregated and deflated

[3] Adopted from (Appleton et al, 1994).

through their weighted prices to have a reasonable approximation of "real" output levels of households.

2. *Farm Labour (L):* Labour input constitutes number of working days of a family, hired worker and individuals in self-help labour exchange (like *Debo*) arrangement among neighbours. In the absence of an easy mechanism to take account of heterogeneity, labour is simply assumed to be homogeneous among individuals.
3. *Land (H):* Land is measured in hectares covered under cereal cultivation during the survey. The survey identified the size of rented land by tenants but failed to separately indicate the kind and amount of inputs used and output produced from this plot. Thus, inputs including land and output values for tenants take into account both on their own and rented-in.
4. *Oxen-Bulls (Ob)*: Number of oxen and bulls is considered as an input because of the problem associated with the reliability of information on the number of ploughing days.
5. *Wealth of Households (M):* Wealth of a household is supposed to positively influence production in several ways. It facilitates the acquisition of inputs and can be used as collateral for credit and reflects efforts of farmers. Wealth of households may exist in different forms but measuring these different items is not simple. Thus, the kind of materials used for roofing is taken as a proxy for wealth and a dummy value of 1 is assumed if the roof was made of wood, galvanised iron, stone, bricks or cement, and 0 otherwise.
6. *Fertilizer (F):* The variable stands for all kinds of chemical fertilisers in kilograms. *Intfhs* is an interaction variable capturing the impact of "large" size (2.5 hectares) land on fertilizer application.
7. *Credit (Cr):* Credit is usually associated with increased production. Thus, those farmers who obtained credit in any of the consecutive years (1984 EC, 1985EC, and 1986EC) are given a value 1 and 0 if it was otherwise.
8. *Soil fertility (Lq) and topography of lands (Ls):* Based on respondents' judgment, fertility and topography are given average values for the different plots of households. Quality of land is encoded as 1=*lem (*fertile), 2=*lem-teuf* (semi-fertility) and *3=teuf* (infertile). Topography is encoded as 1=*medda* (flat), 2=*dagath-ama* (semi-flat) and 3=*geddel* (steeply).
9. *Age of household head and its Square (lA2):* is considered as a proxy variable for farmers' experience and 'endurance' given that agricultural activities require strength and long-time practices on activity management and timing (Mulat and Croppenstedt 1998).

10. *Rainfall (R2, R3, and R4):* Timing, magnitude and intensity of rainfall are indispensable variables in modelling agricultural production. Based on respondents' judgement, *R2* takes a value of "1" if there was sufficient rain at the beginning of *Meher* season, and "0" in the case of excess or shortage. *R3* takes a value of "1" if there was sufficient rain during the growing period of cereals, and "0" in the case of excess or shortage and *R4* assumes a value of "1", if the rain stopped on time and 0 otherwise.
11. *Family Size (FS):* Family size, number of persons in a household, is assumed to influence production as a source of labour and trigger for enhanced output for consumption.
12. *Education*: Education has a bearing on accessing and making use of information to improve the production process. The impacts of different education variables are examined.
    i) *EDLC* takes a value of "1" if the household head obtained a certificate for Adult Literacy Programme or attained a minimum of three years of formal education and "0" otherwise.
    ii) *LEDH1* takes "0" if the household head had no formal schooling or adult literacy certificate and "2" if he reads and writes or obtained adult literacy certificate or religious or traditional education. "3", "6", "8", and "12" are values for those who attained primary but failed to complete, completed primary, completed junior secondary and completed high school, respectively.
    iii) *EDH* is given a value of "1" if there is a member in the household other than the head, who can read and write, and 0 otherwise, with the intention of capturing the influences of literate family members on decision making.

4. EMPIRICAL FINDINGS

4.1 Descriptive Statistics

4.1.1 Source of Data and Over all Feature of the Sample

The first round of Rural Household Survey of Addis Ababa University covered 1477 households from 18 peasant associations (PA) located in 15 w*oredas* of 6 regional states. Observations with erroneous or incredible figures, inconsistent entries, missing and extreme values were excluded in the present analysis. Even though there is not a rule of thumb, households cultivating less than 0.25 hectares of land or who used less than 60 working days and producing less than a quintal in the main agricultural season (*Meher*), were not considered as farmers, hence left out.

Table 1: Regional Distribution of Sample Households

Region	Zone	*Woreda*	Peasant Association (PA)	No. of Households
Amhara	East Gojjam	Enemay	Yetmen	31
Amhara	North Shewa	Debre Berhan	Milki	41
Amhara	North Shewa	Debre Berhan	Kormargefia	28
Amhara	North Shewa	Debre Berhan	Karafino	18
Amhara	North Shewa	Debre Berhan	Fajina Bokafia	19
Amhara	North Shewa	Ankober	Dinki	10
Oromiya	East Shewa	Adda	Sirbana Godeti	61
Oromiya	East Harerge	Kersa	Adele Keke	30
Oromiya	E. Shewa	Spacemen	True Ketchum	53
Oromiya	Arsi	Dodota	Korodegaga	20
SNNP	North Omo	Bolossosore	Gara Goda	16
SNNP	Kembata	Kedia Gemila	Aze Deboa	13
Total				**340**

Source: Own computation

Table 2: Spatial Distribution of Sample Households (HHs) by Land Holding Arrangement

Region	Peasant Association (PA)	Owner-Operators		Tenants/Framers Rented in Land		
		HHs	% Share	HHs	% Share	%Share HHs in PA
Amhara	Yetmen	10	5.1	21	14.6	67.7
Amhara	Milki	21	10.7	20	13.9	48.9
Amhara	Kormargefia	9	4.6	19	13.2	67.9
Amhara	Karafino	10	5.1	8	5.6	44.4
Amhara	Fajina Bokafia	13	6.6	6	4.2	31.6
Amhara	Dinki	6	3.1	4	2.8	40
Oromiya	Sirbana Godeti	46	23.5	15	10.4	24.6
Oromiya	Adele Keke	21	10.7	9	6.3	30
Oromiya	Korodegaga	18	9.2	2	1.4	10
Oromiya	Turufe Ketchema	32	16.3	21	14.6	39.6
SNNP	Gara Goda	6	3.1	10	6.9	62.5
SNNP	Aze Deboa	4	2.0	9	6.3	69.0
Total		**196**	**100**	**144**	**100**	**42.4**

Source: Own computation

Some 196 owner-operators (58%) and 144 tenants (42%), (340 households all together) were considered from twelve different sites of three regional states, the respective shares being 43%, 48% and 9% from Amhara, Oromiya and Southern Nations and Nationalities People (SNNP). From those farmers who rented-in land, Amhara region alone had 54 %, the remaining being distributed between two regions. Tenant farmers relatively dominated in number in Yetmen and Kormargefia of Amhara, and Gara Goda and Aze Deboa of SNNP, while owner-operators concentrated more in other areas.

Among other factors, the type of agro-ecology prevailing and farming technology employed in sample areas have their impact on input-output relationships. Taking account on this, despite some marginal differences, an attempt has been made to consider areas with similar agro-ecology and farming technology. Accordingly, the dominant farming technology is ox-plough among sample areas except that hand hoe is used side by side in Aze Deboa of SNNP. Using or not using of fertilizer has a significant role in determining the kind of technology that farmers employ, and hence the study considers only predominantly fertilised farms. Eight peasant associations, holding about 58 % of the sampled households, cultivated cereal production twice a year; the rest were unimodal with no possibility for *Belg* production. Summing up outputs of two seasons regardless of weather modality might provide deceptive efficiency differentials across places. Thus, only the production of the *Meher* season is considered as annual output across areas. Similarly only the inputs used for the *Meher* season are taken into account.

4.1.2 Own-Operators versus Tenants

About 20% of owner-operator households were female headed, while it was about 8 % in the case of tenants. Female-headed tenant households owned 2.2 oxen and bulls, consisted of 1.75 male adults above 15 years of age and operated on 1.49[4] hectares of land on the average, the corresponding figures for owner-operators being 0.93, 1.15 and 1.52. Except land size, observed differences are statistically significant. Regarding the stock of labour, 5.6 % of owner-operators did not have a male family member above the age of 15 years. For this reason they used hired or under-age farmers. This labour shortage affected only (0.4%) of tenant households.

[4] Of this 1.04 (67percent) hectare was rented in.

The average age of family heads and adult household members who worked on farming and other activities were 48.9 and 36.4 years for owner-operators and 45.1 and 33.5 years for tenants, respectively. Gaps were found to be statistically significant, as it has been the case in many other studies that tenant households had a better stock of younger members. Dependents per household were almost the same, 2.28 for owner-operators and 2.23 for tenants.

With respect to draught power, the difference being statistically significant, owner-operators and tenants on average possessed 1.51 and 1.92 ox-bulls, respectively. Around 28% and 16% of owner-operators reported shortage of oxen and labour, respectively at the right period. The corresponding figures for tenants were 21% and 12%.

Tenant households were found to be relatively wealthier with a statistically significant difference. Around 51% of tenant households resided in houses with a roof made of galvanised iron, bricks, cement or wood, while only 40% own operator households had this opportunity. Educational status and radio possession could be used as a measure for accessing and making use of information on new technologies and marketing. In this respect, nearly 40% of tenant and 32% owner-operator household heads obtained Adult Literacy Program Certificate or attained formal education for 3 years or above. 17% of tenant and 13% of own operator households attended programmes over their own radios.

Table 3: Oxen and Bulls Ownership Status: Owner Operators and Tenants

Number of Oxen and Bulls	Owner-Operators		Tenants/Rented-in Land Farmers	
	% Share	Cumulative %	% Share	Cumulative %
Zero	34	34	23	23
One	28	62	26	49
Two	13	75	22	71
Three and Above	25	100	29	100

Source: Own Computation

The average cultivated land area was 1.93 hectares and for owner-operators and 1.81 hectares for tenants. About 60% of the land operated by tenants was acquired by renting. The quality of land under tenant farmers was slightly inferior, but the difference is not statistically significant. Both groups were operating on similar terrain. Thus, this result does not strongly support the opinion that rented-out holdings are usually inferior in quality. Due to the fact that tenants are found relatively wealthier and well informed, the view that owner-operators rent out their land to unwisely extract surplus from poor renters may not be acceptable, at least in the case of sample households. On the contrary, a tenancy arrangement is found to adjust different landholding sizes with labour, draught power and other complimentary inputs.

The findings do not support either the Marshallian view which assumes tenants to under supply variable inputs. For instance, owner-operators applied 60 kg chemical fertilisers per hectare of land, while it was as much as 75 kg in the case of tenants. Tenants and owner operators spent 181.2 and 136.5 working days per hectare of land and ploughed 13.6 and 9.4 times, respectively. These differences are statistically significant at conventional probability values. A detailed scrutiny revealed that tenants spent more labour time on ploughing and harvesting while owner operators gave more value to weeding.

The observed differences in resource endowment are reflected in output, mean *Meher* cereal production being 12.3 and 13.2 quintals for own-operators and tenants, respectively. However, this gap is not statistically significant.

4.2 Econometric Findings

Visual observation and statistical diagnostic checks through SPSS statistical package were used to clean the data. Normality was checked for non-dummy variables through graphs and variance-covariance matrices. Colinearity is a common problem in most data sets and is accordingly taken care of. For instance, the variance-covariance matrix of age of the household head and its square being singular, Limdep 7 Programme did not entertain the estimation. Ploughing days could have better indicated the contribution of oxen and bulls in the production process rather than the mere number of animals, but it was found highly collinear with the total number of working days (0.91). Indeed, all estimated models in this study were corrected for heteroscedasticity, and the coefficients are standard-error robust estimates.

4.2.1 Production Function and Technical Efficiency: The Whole Sample

A. Production Function Results

OLS and MLE estimates of stochastic frontier Cobb-Douglas production function are presented in Table 4. Most coefficients hold a priori expected signs and were found to be statistically significant. Assuming other factors to be constant, a 1% percent change in the size of land and oxen & bulls could bring about more than 0.32 and 0.26 percent change in output, respectively. The coefficient of labour (L) is significant at 1% and 5% in the OLS and MLE, respectively. The elasticity is relatively low (0.15) perhaps due to less scarcity of labour in rural Ethiopia. Albeit, family size variable is insignificant at conventional probability values, and they might justify the result on the labour input coefficient. Land quality and topography definitely affect both the intensity of farming activities and production. The variable for topography is found to be statistically insignificant as many of the holdings in the sample were by chance flat (*medama*). Quality of land coefficient was found insignificant at 10% degrees of confidence in OLS; and it is statistically different from zero in MLE implying there is a tendency for output to improve as quality of land improves. With respect to direct inputs, more of the variation in output could come from changes in the size of land and draught power as they are relatively scarce.

In the second group, many variables substantially influence the level of production. R2 and R3 are significantly different from zero, confirming the critical importance of rainfall in Ethiopian agriculture. Citrus paribus, if the rain did not come on time with adequate amount at the beginning, it could significantly reduce output. If cereals receive adequate rainfall in the germination and growing periods, it may not be a serious problem at what time the rain stops.

Elasticity of fertilizer with respect to output is around 0.23. This might be low[5] if it is seen in light of farmers' expectations and the responsiveness of land and oxen-bulls. Given its better response than labour and land quality[6], increasing the use of fertiliser is the available feasible way of enhancing production in the face of shortages in the supply of land and oxen & bulls. The interaction variable for fertiliser and land size

[5] While chemical fertilizer is supposed to substantially enhance the level of production, its effects largely depend on the prevailing weather condition, timely delivery and application [Croppenstedt and Mulat, 1997].
[6] Recall that land quality and topography are encoded in the data set inversely to the impact they are supposed to exert on production.

shows a negative sign with insignificant coefficient. This might, however, have an indication that farmers with relatively small holdings tend to fertilize the larger percentage of their holdings while those farmers having more than 2.5 hectares of land do not proportionally make use of fertilizer.[7]

Table 4: OLS and MLE Estimates of Stochastic Frontier Cobb-Douglas Production Function

Variables	O L S		M L E	
	Coefficients (t-ratios)	**Probability Values**	**Coefficients (t-ratios)**	**Probability Values**
Constant	4.057 (7.19)	0.000	4.614 (7.746)	0.000
L	0.1533 (2.67)	0.008	0.1384 (2.168)	0.03
H	0.3256 (3.315)	0.001	0.3213 (3.13)	0.002
OB	0.262 (3.789)	0.000	0.2597 (3.56)	0.000
M	0.4062 (4.837)	0.000	0.40 (4.6810	0.000
CR	0.2847 (3.004)	0.000	0.2923 (3.377)	0.001
R2	0.560 (4.78)	0.000	0.5354 (4.606)	0.000
R3	0.291 (2.46)	0.01	0.2868 (2.6160	0.009
R4	-0.241 (-0.2)	0.840	-0.3063 (-0.255)	0.799
Lq	-0.103 (-1.57)	0.116	-0.1126 (-1.72)	0.08
Ls	-0.9 (-0.759)	0.45	-0.1017 (-0.799)	0.424
Edh	-0.54 (-2.52)	0.012	-0.5052 (-2.515)	0.01
F	0.2315 (3.71)	0.000	0.2344 (3.79)	0.000
Intfhs	-0.783 (-0.293)	0.76	-0.1149 (-0.374)	0.709
La	0.116 (0.87)	0.38	0.1206 (0.885)	0.376
Ledh1	0.232 (2.19)	0.001	0.2339 (3.39)	0.001
Lfs	-0.125 (-1.343)	0.1793	(-1.255)	0.21

Source: Own computation

[7] The average per hectare fertilizer application for a land size less than 2.5 hectares is 96.16 kg while the respective figure for land size larger than 2.5 hectares is 64.05 kg.

Wealth and credit dummies (M and CR) maintained their expected positive sign with elasticities of 0.40 and 0.28, respectively. Households the roofs whose homes were made of galvanised iron, stone, bricks or cement produced higher levels of output. This might be due to the fact that these farmers could relatively be liquid to acquire the necessary complementary inputs on time. It is also possible to argue that in the Ethiopian context constructing a house with galvanized iron requires producing over and above the customary consumption requisite of the household at least for sometime, which could demonstrate accumulated efforts and experiences on farming. On the other hand, households with grass-made-roofs are forced to waste part of their productive time on housing maintenance, and above all more often than not they are economically less established.

Educational variables revealed that literate farmers are more productive than illiterates owing perhaps to better access to information about the source and use of modern inputs, as well as better commitment in adopting modern farming techniques and management practices.[8] The variable for literate family members other than the head, EDH, came up with a negative sign and became significantly different from zero. A partial correlation between EDH and the variable for adult family members indicated a very weak association[9], implying that many are under "farm-age" with little experience to share and influence the decision of the household head, thus rather compete for limited financial resources and working time in an attempt to take care of them while they are learning.

The variable for age of household head, (Ia), is found to be insignificant. The average age of household heads was more than 45 years, such that there were many "old" family heads. Naturally, two possibly contradictory effects may arise beyond a certain age limit; boosting production through rich experience or losing physical strength/endurance to accomplish day-to-day activities (Croppenstedt and Mulat 1997).

[8] Studies on the area indicated that education is believed to influence after a certain threshold level. However, as descriptive statistics figures indicated educated farmers are rare and discrimination based on education levels may not provide meaningful result. We also learnt from the findings of Abay (1997) on a similar data set that in the Ethiopian peasant agriculture, any level of education for the household has positive contribution to production.

[9] The result shows a negative sign with a partial correlation coefficient of 0.14.

4.2.2 Technical Efficiency

As indicated in Table 4 above, production function estimates through OLS illustrate mean output responses of "all households" for a change in input levels, while MLE, as a stochastic frontier estimator, reveals the same but considers the "best-practising" farmer as a reference. OLS gives no room for impacts of specific household attributes and assumes similar efficiency levels across farmers. Obviously, the value of the constant term in OLS should be lower or equal to the MLE (Assefa 1995). Thus, the values of the constant terms are 4.057 in OLS and 4.614 in MLE, indicating the existence of efficiency difference among farmers due to household controlled "errors in operation". The difference between the two values measures how far the best-practising farmer operates above the average production line.

Table 5: Estimates of Technical Inefficiency Indicators

Parameters	Coefficients (t-ratios)	Probability Value
σ_{μ}^{2}	0.37015	
σ_{v}^{2}	0.3399	
σ^{2}	0.8379 (8.6)	0.00
$\lambda = \sigma_{\mu}/\sigma_{v}$	1.056 (2.2)	0.026

Source: Own computation

The effect of household controlled factors on the variation of production levels, σ_{μ}^{2} are found 8.9 percent more compared to the case for exogenous variables σ_{v}^{2}. Similarly, the coefficient of λ also indicated that the one-sided error term has statistically significant and higher influences than the conventional error term, implying that factors that are under farmers' control exert more influence than otherwise. Thus, there exists inefficiency in sampled households due to in-house problems and the extent varies among farmers operating even in a similar technological setting.

Table 6: Technical Efficiency of Farmers by Education Status, Land Size and Regions

Statistics	Whole Sample	Education Status		Land Size		Regional States		
		Literate	Illiterate	Two Ha & below	Above two Ha	Amhara	Oromiya	SNNP
Minimum	0.220	0.307	0.220	0.370	0.220	0.243	0.301	0.220
1st Quartile	0.379	0.439	0.379	0.480	0.379	0.384	0.439	0.314
Mean	0.628	0.639	0.625	0.633	0.627	0.638	0.645	0.426
Median	0.641	0.656	0.631	0.648	0.639	0.654	0.665	0.431
3rd Quartile	0.696	0.703	0.696	0.700	0.696	0.667	0.756	0.500
Maximum	0.855	0.836	0.857	0.855	0.810	0.808	0.855	0.594

Source: Own computation

Mean technical efficiency of all sample households is 62.8% relative to the "best-practicing" farmer. Due to the incapability of optimally utilizing resources under their disposal, households on the average loose about 37.2% of their potential output. About a 63 % difference was observed between the efficient farmer next to the best and the most inefficient one. The first 25% inefficient farmers operated very much below the mean, where as the top 25% farmers performed very much near to the centre. The median, being higher than the mean and the first and third quartiles imply negatively skewed distribution of technical efficiency values. This implies a considerable efficiency difference amongst lower efficiency level operators than the case for relatively "efficient" ones.

Efficiency varies between groups of farmers classified under different attributes. Literate farmers realized higher output per unit of inputs than illiterates and similar variation is also observed in resource endowment and input use. Literate farmers had larger stock of oxen and bulls, applied more fertilizer and obtained more credit[10]. On average, farmers having two or less hectares of land performed more efficiently than those having more than two hectares of land. This might be because of incompatibility of other resource endowments with the size of the cultivated land[11].

[10] While literate farmers on the average used 135.4 kg fertilizer, owned 1.72 ox-bulls and 25% of them acquired credit, the respective figures for illiterate farmers were 118.3, 1.67 and 22%.
[11] Small land farmers spend 99.32 kg chemical fertilizers, 208.44 labour days and 1.2 oxen and bulls per hectare of land while large size farmers use 54.29 kg, 134.53 labour days and 0.86 ox-bulls. In terms of quality of land, the mean

Thus, reallocation of land through tenancy or otherwise has an implication not only on equity but also efficiency gains. Efficiency is also affected by location factors. Farmers of Oromiya were relatively efficient on average than those in Amhara and SNNP, which stood second and third, respectively. Partly this difference was attributable to the magnitude of input utilization and natural conditions.[12] SNNP farmers employed relatively low level of labour, oxen and bulls, and fertilizer and Amhara farmers operated under unfavourable natural conditions in terms of the pattern of rainfall and land quality.

4.3 Efficiency Difference between Owner-Operators and Tenants

Chow-test is used to examine whether or not land ownership leads to different production functions. The required parameter estimates and the respective computed F-value for the test are the following.

Table 7: Chow Test Parameters

Residual Sum of Squares	Number of Observations	F- Statistics
s1= 158.54	N1 = 196	F- computed = 1.56938
s2 = 102.35017	N2 = 144	F (17, 306) at 1% ≈ 2.62
S3 = 43.48569968	K = 17	F (17, 306) at 10% ≈1.74

Source: Own computation

The computed F-value based on equation (17) is lower than the critical F-values at conventional probability magnitudes. Thus, we do not reject the hypothesis that owner-operators and tenants work on the same production function, implying that tenancy related factors such as rent, obligations to be carried out by tenants, land use insecurity, etc., did not have the strength to characterize a different kind of production function. Under such circumstances, comparing efficiency levels between the two groups of households is possible on the basis of a common stochastic frontier production function.

figures are in favour of the small land holders (1.65) compared to the others (1.79). Given the lowest elasticity of land quality variable holds, the main cause of inefficient operation for 'large' lands could be incompatibility of resources.

[12] Details are provided in Appendix No. 4¹

Table 8: Efficiency Comparison between Own-operators and Tenant Farmers

Statistics	Whole Sample	Owner-Operators	Tenants
Minimum	0.22044	0.24255	0.22044
First Quartile	0.3790	0.39558	0.36463
Median	0.64056	0.63926	0.64115
Third Quartile	0.69610	0.70163	0.65301
Maximum	0.85465	0.85465	0.79720
Mean	0.62757	0.629416	0.6251
Mean at 95% Confidence Interval	0.6446	0.6464	0.6423

Source: Own computation

As revealed from Table 8, central tendency measures except the median gauged owner-operators to be relatively more efficient as compared to tenants. Besides, the most efficient and the most inefficient farmers were among own-operators and tenants respectively. However, this gap in efficiency between the two groups of farmers is not statistically different from zero, (F=0.125).

Owner-operator and tenant dummy variables were incorporated into two production functions to examine their associations with output. The coefficient of the dummy variables for owner-operators and tenants became positive and negative, respectively, but statistically insignificant in both cases.[13] Thus, both statistics and econometric findings do not provide a strong support for the view that 'tenants are inefficient because of several institutional constraints'.

The opinion that rental share discourages efficiency of tenants does not adequately consider the opportunity cost of tenant labour at least in the Ethiopian context. In our case, tenants did not meaningfully use hired labour and their non-farm income was very limited[14]. The need for survival in the face of limited opportunities could influence farmers having limited access to land to operate at least with the prevailing input application norms and demonstrated a similar efficiency level with owner operators. In addition to operating in a similar technological setting in terms of using

[13]The coefficient of owner-operator dummy (wn) in OLS with associated t-ratios is found to be 0.774 (0.95) while the respective figures for tenant dummy (tt) are -0.774(-0.95). See Appendix 3

[14] The average non-farm income of households is 19 US Dollars (143.17 *Birr*) per annum.

fertilizer and ox-plough, farmers who rented-in land were relatively better endowed with resources.

To examine possible input specific responsiveness differences, elasticity of labour, land, oxen and bulls, fertilizer and rainfall are estimated for own operators and tenants using MLE and a Wald test is applied.

Table 9: MLE Estimates of Cobb-Douglas Production Functions for Wald Test

Variables	Owner-Operators		Tenants		For the Two Groups		
	Coefficients	Standard Errors	Coefficients	Standard Errors	Sum of β Variances	Square of βs Differences	$\chi^2_{(1)}$
Constant	3.65678*	0.41800	4.005712*	0.39308	0.329241	0.1217	0.37
L	0.18575*	0.088634	0.933352	0.016146	0.012031	0.5589	46.5
H	0.10921	0.113296	0.601790*	0.115578	0.026241	0.24263	8.62
OB	0.25962*	0.094693	0.16979*	0.098892	0.018747	0.00807	0.43
R2	0.58851*	0.0128918	0.813287*	0.128468	0.016674	0.05052	3.03
F	0.34954*	0.0829694	0.321019*	0.802091	0.013623	0.11284	8.28
Ledh1	0.18404*	0.0897825	0.985686	0.780618	0.077425	0.6426	8.23

Source: Own computation *Significant at 5%.

No statistically valid difference is observed between intercepts, the coefficients of oxen and bull, and rainfall variables in the two production functions (as critical value for $\chi^2_{(1)}$ at 5% = 3.84). With respect to other inputs, statistically significant output elasticity differences are noticed. Output fairly responds to fertilizer application in both farms but higher in the production function of owner-operators. Land in owner-operators' and education and labour in tenants production function are found statistically insignificant. This tends to imply that land in owner operators and labour for tenant households' are relatively in abundance, which calls for a sort of adjustment through perhaps tenancy arrangements.

5. CONCLUSION AND POLICY IMPLICATIONS

Mean technical efficiency of sampled households is about 62.8 percent implying that a considerable potential exists for production gain with the given technology. Households with two hectares or less performed better than those having larger farms, possibly because of the fact that those operating on two or more hectares of land may not have adequate complementary resources to make use of the land effectively. Literate farmers were relatively wealthier, more informed and efficient and had better access to credit markets. Wealth of households, credit, oxen and bulls, amount of fertilizer and rainfall significantly contribute to production.

Mode of land holding did not bring about an observable difference in mean technical efficiency between owner-operators and tenants (62.9 percent and 62.3 percent respectively) and both groups operated on a similar production function. Coefficients of dummy variables representing owner operators and tenants, in two alternative cases in a production function, revealed a positive and a negative sign, respectively, but they were statistically insignificant. This consistent outcome from quite different methodologies arose possibly from at least two important factors. Firstly, in the face of limited alternative employment opportunities, tenants may not even contemplate to undersupply inputs and efforts rather than maximizing their share of output. Secondly, land mobility may allow better compatibility of resources for both groups of farmers and this could be witnessed from the fact that those farmers having more than two hectares of land were found less efficient.

From the above findings, the following policy implications could be derived. Efforts towards providing training, education, and extension services for households focusing on optimal use of available inputs should be underpinned. Government should also encourage the establishment and expansion of micro credit institutions and mechanism should be created for the movement of production factors such as oxen and bulls across areas for better economic and social return. Minimizing dependence on rainfall for cereal production calls for a coordinated effort among donors, government and beneficiaries to pool resources and formulate programs to undertake small-scale irrigation schemes.

It has already been observed from the result in this study that rental arrangement of land has been used as a mechanism of adjusting input combinations for their efficient use. Thus, it would be for the mutual benefit of landholders with inadequate complementary inputs, including male labour and oxen, and those who own very small plots or absolutely lack access to state land to continue working together through tenancy arrangements. A thorough study might be required to propose a conclusive recommendation about the impacts of contracts on efficiency, yet as evidenced from past experiences in different countries, the higher the rental shares the more reluctant tenants would be to maximize output. This calls for arrangements that would provide optimal benefits to both parties.

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Annex 1

Descriptive Statistics of Some Key Variables for the Whole Sample

Variables	Mean	Standard Deviation	Minimum	Maximum
Value of Output in Birr	1857.48	1633.77	77.5	13886.0
Land in Hectares	1.88	1.25	0.25	9.25
Labour Days	290.75	322.06	60.0	2253.0
Fertilizer in Kg	124.15	106.52	34.0	800.0
Oxen and Bulls	1.69	1.79	0.0	14
Land Quality	1.69	0.64	1.0	3.0
Land Topography	1.23	0.34	1.0	3.0
Family Size	7.03	3.26	1.0	22
Adults above 15yrs of Age	1.95	1.2	0.0	9
Dependent	2.26	1.63	0.0	11
Age of HH Head	47.3	16.2	18.0	90.0
Age of Adults	35.2	9.7	19.0	85.0
Hired Labour Share	0.13	0.22	0.00	1.0
Exchange Labour Share	0.19	0.23	0.00	0.91
Family Labour Share	0.68	0.29	0.00	1.00
HH Taking Credit	0.23	0.42	0.00	1.00
Female Headed HH	0.15	0.36	0.00	1.0
EDLC	0.34	0.47	0.00	1.0
HH Members Yrs of Schooling	1.33	1.99	0.00	10.0
Credit	0.23	0.42	0.00	1.0
Non-Farm Income	143.17	353.68	0.00	4500.00
HH with Galvanized Iron Sheet Residences	0.45	0.50	0.0	1.0
HHs with Radio	0.15	0.35	0.00	1.00
HHs with Labour Problems	0.14	0.35	0.00	1.00
HHs with Oxen Problems	0.25	0.43	0.00	1.00
Water Acquiring Time in Minutes	15.18	20.27	0.00	300.0
Firewood Acquiring Time in Minutes	39.86	57.86	0.00	420.0

Source: Own computation.

Annex 2

A Comparative Analysis of Mean Values: Owner operators -vis-à-vis- Tenants

Variables	Owner operators	Tenants	F-Value
Age of Household Head	48.9	45.1	4.85
Average Age of Adults (Ag)	36.4	33.5	7.82
Dependents	2.28	2.23	0.17*
Oxen and Bulls	1.51	1.92	4.45
HH with Galvanised Iron Sheet (%)	40	51	4.1
Radio Possession (%)	13	17	1.4*
EDLC (%)	32	38	1.3*
Output in Kg	1229.2	1316.3	0.5058*
Fertiliser in Kg	115.2	136.3	3.26
Land in Hectares	1.93	1.81	1.27*
Labour	263	328	3.38
Credit	0.24	0.34	0.406
Labour for Ploughing	61.1	82.4	5.97
Labour for Harvesting	111.0	164.17	4.42
Labour for Weeding	91.2	81.5	3.35
No. of times (Ploughing)	9.4	13.6	39.4
Share of Family Labour (%)	66	72	3.36
Share of Hired Labour (%)	12.3	12.2	0.002*
Share of Exchange Labour (%)	22	16	4.9
Edh1	1.34	1.33	0.00*
Output per Labour	7.1	6.4	0.9
Output per Oxen and Bulls	713.4	757.8	0.23*
Land in Hectares	1.93	1.81	1.35*
Land Quality	1.65	1.75	1.75
Land Topography	1.23	1.22	0.05*
Female Headed Households (%)	20	8	8.8
No of Adult Farmers	1.95	1.96	0.004*
Family Size	7.2	6.8	1.15*
HHs having Labour Problem at Right Time (%)	16	12	1.1*
HHs having Oxen and Bulls Problem at Right Time (%)	28	21	2.01*

Source: Own computation

Annex 3

1. The Role of Landholding Status in Production- Tenant Dummy as an Explanatory Variable

Limited Dependent Variable Model – Frontier Regression
Ordinary Least Square Regression Weighting Variable = None
Dependent Variable = Y, Mean = 6.7644505, S.D. = 0.9490891482
Model Size: Observations = 340, Parameters = 18, Deg. Fr. = 322
Residuals: Sum of Squares = 158.1004192, Std.Dev. = .70071
Fit: R-squared = .482251, Adjusted R-squared = .45492
Model Test: F[17, 322] = 17.64, Prob value = .0000
Diagnostic: Log-L = -352.2675, Restricted (b = 0) Log-L = -464.1725
LogAmemiyaPrCrt. = -.660, Akaike. Info.Crt = 2.178

Variable	Coefficient	Standard Error	B/St.Er	P[/Z/>z]	Mean of X
Constant	4.126409098	.56877315	7.255	.0000	
L	.1535615947	.57552686E-01	2.668	.0076	5.3046580
H	.3313662366	.98425544E-01	3.367	.0008	.43139455
OB	.2649724730	.69328448E-01	3.822	.0001	.79383793
M	.4135022841	.84339787E-01	4.903	.0000	.45000000
Cr	.2838728559	.93623033E-01	3.032	.0024	.23235294
R2	.568137203	.11740638	4.839	.0000	.36764706
R3	.2790552552	.11892414	2.346	.0190	.35294118
R4	-.2705668449E-01	.12029103	-.225	.8220	.30294118
Lq	-.1001067377	.65626101E-01	-1.525	.1272	1.6933326
Ls	-0.9170590944E-01	.11867592	-.773	.4397	1.2310305
EDH	-0.5423866304E-01	.21514671E-01	-2.521	.0117	1.3340900
F	.2337389606	.62507030E-01	3.739	.0002	4.5338446
Intfhs	-.629271467E-02	.26803113E-01	-.235	.8144	2.3918206
LA	.1016174478	.13422378	.757	.4490	3.7866718
LFS	-.1276985208	.92913398E-01	-1.374	.1693	1.8436391
LEDH1	.2351289870	.72744076E.01	3.232	.0012	.47816286
TT	-.7736025823E-01	.81130687E-01	-.954	.3403	.42352941

Source: Own computation

2. The Role of Landholding Status in Production- Owner operators Dummy as an Explanatory Variable

Limited Dependent Variable Model – Frontier Regression
Ordinary Least Square Regression Weighting Variable = None
Dependent Variable = Y, Mean = 6.7644505, S.D. = 0.9490891482
Model Size: Observations = 340, Parameters = 18, Deg. Fr. = 322
Residuals: Sum of Squares = 158.1004192, Std.Dev. = .70071
Fit: R-squared = .482251, Adjusted R-squared = .45492
Model Test: F[17, 322] = 17.64, Prob value = .0000
Diagnostic: Log-L = -352.2675, Restricted (b = 0) Log-L = -464.1725
LogAmemiyaPrCrt. = -.660, Akaike. Info.Crt = 2.178

Variable	Coefficient	Standard Error	B/St.Er	P[/Z/>z]	Mean of X
Constant	4.049048840	.56416411	7.177	.0000	
L	.1535615947	.57552686E-01	2.668	.0076	5.3046580
H	.3313662366	.98425544E-01	3.367	.0008	.43139455
OB	.2649724730	.69328448E-01	3.822	.0001	.79383793
M	.4135022841	.84339787E-01	4.903	.0000	.45000000
Cr	.2838728559	.93623033E-01	3.032	.0024	.23235294
R2	.568137203	.11740638	4.839	.0000	.36764706
R3	.2790552552	.11892414	2.346	.0190	.35294118
R4	-.2705668449E-01	.12029103	-.225	.8220	.30294118
Lq	-.1001067377	.65626101E-01	-1.525	.1272	1.6933326
Ls	-0.9170590944E-01	.11867592	-.773	.4397	1.2310305
EDH	-0.5423866304E-01	.21514671E-01	-2.521	.0117	1.3340900
F	.2337389606	.62507030E-01	3.739	.0002	4.5338446
Intfhs	-.629271467E-02	.26803113E-01	-.235	.8144	2.3918206
LA	.1016174478	.13422378	.757	.4490	3.7866718
LFS	-.1276985208	.92913398E-01	-1.374	.1693	1.8436391
LEDH1	.2351289870	.72744076E.01	3.232	.0012	.47816286
WN	.7736025823E-01	.81130687E-01	-.954	.3403	.57647059

Source: Own computation

Annex 4

Average Input application and Natural Conditions of Farmers across Regions

Variables	Amhara	Oromiya	SNNP
Labour Days	281.6	323.16	153.7
Oxen and Bulls	2.16	1.40	0.86
Land Quality	1.94	1.46	1.76
Fertilizer in Kg	120.7	139.47	61.54
Rainfall Comes on Time	0.45	0.70	0.63

Source: Own computation