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PUBLIC INVESTMENT ON RURAL ROAD TRANSPORT AND ITS EFFECT ON AGRICULTURAL CROP PRODUCTION: EVIDENCE FROM ETHIOPIAN LIVING STANDARD MEASUREMENT SURVEY (LSMS)

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ABSTRACT

Public investment on rural road transport system is an important factor affecting the growth and transformation of agriculture. Considering this fact, Ethiopia has made relatively massive investments in the development of roads to tackle isolation and improve the welfare of the rural poor. However, despite such efforts, rural road development indicators show that Ethiopia's rural road transport has still remained low. As a result, close to 70 per cent of the rural population in Ethiopia still travels about six hours to reach all-weather roads. Besides, most rural roads are dry weather roads that cannot be passable by any formal transport modes during the wet season. Against this background, we investigated the effect of rural transport (access and mobility) on crop production in Ethiopia using a unique panel data from rural Ethiopia. We used both descriptive statistics and Econometric model to understand the effect of rural transport on crop production. The result of the analysis revealed that there exist low utilisation of modern mode of transport for agricultural activities and by far foot is still largely dominant mode of transport for agricultural purposes. On the other hand, the Econometric analysis revealed an interesting result. That is, while access to all-weather roads has a positive but insignificant effect on crop production, the effect of mode of transport was found to be positive and significant. The policy implication is improving rural roads to a level of all-weather road standards and provisions, and transport facilities should still be a priority for policymakers.

Keywords: Rural Road Investments, Access to Road, Mode of Transport, Cobb-Douglas Production Model, Fixed Effect, Random Effect.

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Introduction

Agricultural growth can serve as an effective driver of economic growth and poverty reduction both within and outside agricultural sectors. Increase in such productivity depends on good rural infrastructures, well-functioning domestic markets, appropriate institutions and access to appropriate technology (Pinstrup and Satoru, 2006). Rural roads are somewhat unique in terms of their capacity to literally pave the way for other investments such as schools, health services, and security services (Fan et al., 2008). According to International Fund for Agricultural Development (2001), access to rural markets and the lack of poor provision of roads are central concerns for rural communities in the developing world. In agriculture sector, better roads can drastically reduce the cost of inputs such as fertilisers, seeds, and extension services (Dercon et al., 2009), and on the output side, rural road access increase the scope of profitable trade, which in turn encourages on-farm investments to raising agricultural production (Khachatryan et al., 2005). Generally, for a nation to develop there is need to construct and maintain roads both in urban and rural areas.

In this regard, a key element in rural development is the ability of the nation to overcome infrastructural constraints, especially that of rural roads in our rural areas. One of the major constraints for the growth of smallholder agriculture in African countries is high transaction costs (Machethe, 2004), largely attributable to poor infrastructure. FAO (1996) stated that though infrastructures are key stimulants to agricultural development and growth, they are limited in all rural areas. Several studies (Fan and Zhang, 2004; Worku, 2011; Decron et al., 2009; Lulit, 2012; Wondemu and Weissb, 2012) have also revealed that investment in infrastructure is essential to increase farmers' access to input and output markets, stimulation of rural non-farm economy and vitalise rural towns. However, the lowest household income groups have limited access to infrastructure (Decron, 2009). Infrastructure, such as irrigation and transport and road systems, together with institutions such as banks and markets, make possible a range of production options that are translated to higher agriculture productivity through technology adoption (Pinstrup-Anderson & Shimokawa, 2006). Thus, investment in infrastructure has the potential to reduce poverty.

Ethiopia has a lowest road density, both in terms of road density per 1000 sq.km and per 1000 population. For example, road density per 1000 sq.km and per 1000 population is 78 km and one, respectively, the total road network of the country is 85,966 km constituting 11301 km of asphalt road and 32582 km of rural roads. Considering this fact, the Ethiopian government has implemented the Road Sector Development Programme (RSDP) to improve the road transportation system in the country since 1990s. More interestingly, the recent five-year growth and transformation promised the construction of 11,212 kms of new rural roads and the construction of 71523 kms of new Woreda roads under its Universal Rural Road Access Programme (MoFED, 2010). However, despite such investment, rural road transport has still remained low. The rural population in Ethiopia still need to travel about seven hours to reach all-weather roads and the average Rural Access Index (RAI) for the country is around 50 per cent (ERA, 2014). The proportion of number of rural population within 2-km access is only 28.8 per cent. The empirical studies on the contribution of rural road access have shown that rural road access can play a meaningful role in fostering rural income and reducing poverty (Worku, 2011; Decron et al., 2009; Lulit, 2012; Wondemu and Wessib, 2012). The extent to which these have helped in increasing crop production of rural farmers is a major area for research and is the main focus of this study.

Data

The empirical data were drawn from two consecutive panel surveys of the Ethiopian Rural Socio-economic Survey (ESS) and Living Standard Measurement Survey (LSMS). These data were prepared by the Central Statistics Agency (CSA) and the World Bank. The first round of survey was conducted in 2011 and the second one was conducted after two years in 2013. In agriculture and rural transport, middle towns and small towns were excluded from the sample. The panel data were created using three criteria.(1) Households must be from rural areas (2) Households cultivated some plot of land and on the other hand, they have to have positive value of production 3) Households with zero or missing values cultivated plot of land, production and expenditure were excluded. Finally, a balanced panel of 2176 households consisting of 4352 observations over two rounds was created[1] .

The data cleaning process required explanation for some of the variables used in the analysis. Farmers reported their cultivated land by using different local units of measurements. Thus, plots cultivated by households measured by local units were converted to standard measure, hectare, using the CSA's conversion factor. Finally, the plot level information was aggregated into household level. Aggregation of real consumption per capita involves four steps. First, total food and non-food expenditures were calculated. Second, the food and non-food expenditures were converted to real expenditure using the CSA's consumer price index. Third, the data were aggregated at household level in order to get total real value of expenditure at household level. Finally, the real expenditure was divided by family size in adult equivalent to get real consumption per capita. Household size in adult equivalent was converted using the nutrition (calorie) equivalence scales prepared by FAO conversion factor.

On the other hand, since quantity of output produced is already measured by standard units (kg and gm) there was no need to convert. However, the quantities reported in gram were converted to kilogram values. The quantity of production (crop and root crops or fruits) was converted to value in Ethiopian Birr (ETB) using the following procedure. First, unit price of each crop was calculated by dividing the value of output sold by the quantity of output sold in the market (this is possible because we have crop level information about the quantity and value sold). This would give the unit price of each crop and once the unit price is obtained, we can simply multiply it by the amount of output produced by each crop to get the total value of each crop produced. However, for those households that did not report any crop sale in the market, the mean village level price of each crop was used to convert quantity of production to value of production. Finally, the nominal value of production was converted to real values using CSA production price data and 2011 was used as a base year. Livestock ownership in tropical livestock units (TLUs) was calculated using the Janke (1982) approach.

Another important issue is measure of the quality of road access and mobility. In the survey, the road quality of the sampled villages was compiled through a structured community level questionnaire. Community leaders were asked to identify the type of community/village roads in their respective villages. Following Dercon, et al., 2009; Wondemu and Weissb, 2012, the road quality of the villages is categorised into two groups. The first one is 'good road access' that indicates access to all-weather roads. The second one is 'poor road access' and it represents roads that do not allow reasonable access throughout the year. Therefore, while estimating the empirical model, a value of 1 is given for villages that have good road access and 0 for villages with poor road access. The other transport indictor variable is mobility or the mode of transport used for agriculture-related activities. In this regard, foot, traditional modes of transport (pack animals, animal drawn carts, one-wheeler, etc.) and modern modes of transport (Bajaj motorcycle, cycle, mini-bus, etc.) were considered.

Methodology

Measuring Production: There are generally two basic approaches in measuring agricultural production in the literature. These important approaches are known as non-parametric approach and the parametric approach. In the case of the parametric approach, the coefficients of the production function are estimated using econometric approach, whereas in the case of non-parametric approach, the coefficients of the production are estimated using mathematical programming approach (Coelli et al., 1996). In this study, the parametric approach was employed to be the appropriate approach to estimate the relationship between accessibility and mobility vs. productivity. This is rational as the parametric approach is commonly used in the estimation of production functions while the non-parametric approach is used in efficiency analysis (Coelli et al., 1996). This approach is also advantageous over the non-parametric approach as it allows statistical tests that would allow hypothesis testing and calculation of confidence intervals to test the reliability of the model estimated (Antle and Susan, 1988).

The theoretical and empirical foundations of production and productivity analysis in agricultural science rely heavily on the Cobb-Douglas production function mainly due to its easy estimation procedures and the possibility to test the significance of the estimated elasticities using standard test statistics (Battese and Coelli, 1995). However, according to Coelli et al. (1996), it has also many restrictive properties imposed on the production structure like fixed returns to scale and elasticity of substitution always equal to unity. This study adopted the Cobb-Douglas production function to estimate the relationship between accessibility, mobility vs. production and accessibility, and mobility vs. productivity. In this regard, the Cobb-Douglas production function can be specified as follows.

$$Y = f(X, z) \quad (1)$$

Where Y is the level of agricultural production, X is a vector of technological inputs like quantity of fertiliser, pesticide, etc., and Z is a vector of physical inputs such as sex, age, education level of household head, farm size, household size, etc. Given this specification of output and inputs, the Cobb-Douglas production function that consider the panel nature of the data in this study can be expressed as:

$$Y_{it} = \pi\,(X_{ijt}^{\alpha j} Z_{ijt}^{\delta j})e^{\gamma + \varepsilon i} \quad (2)$$

Where Y_{it} is the yield response of the i^{th} area of land in period t; X_{ijt} is the use of the i^{th} area of the j^{th} technological input in period t; Z_{ijt} is the use of the ith area of the j^{th} physical input in periodt.

The empirical speciation for the production model is presented using the Cobb-Douglas theoretical production model. In order to drive the empirical model for production let us assume that we have two classical factors of production or inputs Land (L), Labour (La) and Capital (K) used in the production of agricultural outputs. Thus, for the purpose of simplification, the simplified version of production model can be written as:

$$y_{it} = \gamma\,(L_{it}^{\alpha_1} La_{it}^{\alpha_2} K_{it}^{\alpha_3})e^{\varepsilon it} \quad (3)$$

Where y_{it} is total value of production of the i^{th} household's all farm output in Ethiopian Birr during Period t, L_i is the i^{th} units of labour used during the production period t, La_{it} is the i^{th} units of land used during the production period t, k_{it} is the i^{th} unit of capital used during the production period t, ε^{it} is the disturbance term of the model, taking the logarithm of both sides of the above production function will give us the linear form of the above equation.

$$\ln y_{it} = \alpha_i + \alpha_1 \ln L_{it} + \alpha_2 \ln La_{it} + \alpha_3 \ln K_{it} + \varepsilon_{it} \quad (4)$$

With the same procedure, this model can be also extended to capture all other variables that affect the level of output (production) of the ith household at period t.

$$\begin{aligned}\ln y_{it} = {} & \alpha_{0i} + \alpha_1 \ln mdays_{it} + \alpha_2 \ln area_{it} + \alpha_3 \inf erti_{it} \\ & + \alpha_4 \ln nooxen_{it} + \alpha_5 \ln farmcapi_{it} \\ & + y_6 age + y_7 edu_{it} + y_8 accredit_{it} + y_9 accext_{it} \\ & + y_{10} accirrig_{it} + y_{11} accroad_{it} + \alpha_{12} transm_{it} + \varepsilon_{it}\end{aligned} \quad (5)$$

The summary of the variables and the expected signs are presented in Table 1.

Table 1: Description of Variables Used in the Production Mode

Variables	Description of the Variables	Exp.sign
lny_{it}	natural logarithm of total crop production for household *i* at time t^2	
$lnmdays_{it}$	natural logarithm of total labour used by the i^{th} household at time *t*	+
$lnarea_{it}$	natural logarithm of farm size in hectare for household i at time *t*	+

(Contd........)

Table 1 *(Contd.....)*

Variables	Description of the Variables	Exp.sign
lnferti$_{it}$	natural logarithm of quantity of fertiliser used by the i^{th} household at time *t*	+
lnnooxen$_{it}$	natural logarithm of number of oxen owned by household *i* at time *t*	+
lnfarmcapt$_{it}$	natural logarithm of number of farm capital owned by household *i* at time *t*	+
age$_{it}$	age of the i^{th} household head at time *t*	-
edu$_{it}$	years of schooling of the i^{th} household at time *t*	+
acccredit$_{it}$	access to credit for the i^{th} household at time *t*	+
accext$_{it}$	extension contact of the ith household in period *t*	+
accirr$_{it}$	irrigation use by the ith households at time *t*	+
accraod$_{it}$	access to all-weather road at time *t*	+
transm$_{it}$	mode of transport used by the i^{th} household at time *t*	+

Source: compiled from various empirical literatures.

Result

The summary of key variables used in the analysis of crop production is presented in Table 2,3 and 4 below.While Table 2 presents the overall mean values of the variables at household level, Tables 3 and 4 presents mean comparison test result for selected variables at household level by the type of accessibility and survey periods, respectively. Accordingly, Table 2 revealed that the mean value of output was 5509.5 ETB. The value of output is later transformed into its logarithmic form in order to keep the assumption of normality. Table 2 shows that 80 per cent of the respondents in the sample are men and the rest are female-headed household representing 20 per cent.The mean value of age is 45.5 with a standard deviation of14.8 from the mean value. The mean value of family size (converted to adult equivalent) is 4.7 with a standard deviation of 1.9.The Table also presented a summary of farm characteristics of the sample households. The mean values of the major conventional inputs for the pooled data were land (2.4 ha), fertiliser (60 kg) and total labour used in mandays (408). Table 2 also gives summary about access to social and agricultural services like extension, credit, irrigation and road access. According to the result, households with access to extension, credit, irrigation, and all-weather road are 40, 20, 10 and 30 per cent, respectively.The mean value of farm asset indicators (number of ploughing oxen, number of farm capital and total livestock units) are 1.5, 4.9 and 6.4.

Table 2: Descriptive Statistics for Variables Used in the Efficiency Model

Variable	Observations	Mean	Std. Dev.	Min	Max
Age of the household head	4351	45.5	14.8358	17	97
Gender of the respondents	4354	0.812	0.38675	0	1
Years of schooling of the head	4354	1.9	2.67943	0	17
Land size (Ha)	4353	2.4	1.85812	0.0012	9.97
Fertilizer (Kg)	4352	60.4	90.5362	1	769.425
Access to extension (yes=1)	4354	0.4	0.48305	0	1

(Contd........)

Table 2 *(Contd.....)*

Variable	Observations	Mean	Std. Dev.	Min	Max
Access to credit (yes=1)	4354	0.2	0.41829	0	1
Access to irrigation (yes=1)	4353	0.1	0.34258	0	1
Access to all-weather road (yes=1)	4354	0.3	0.45038	0	1
Total value of output	4354	5509.5	8956.98	2.5	138815
Number of ploughing oxen	4354	1.5	0.95564	1	14
Farm capital (number)	4354	4.9	3.34533	1	31
Family size in adult equivalent	4354	4.7	1.90766	0.74	12.95
Total labour used in mandays	4354	408	329.537	0	1353.25
Total number of livestock owned	4354	6.720	6.42	0	69

The mean value comparison for key variables by the type of rural road accessibility is presented in Table 3. The result shows that there is significant difference in irrigation use, real value of output produced, between households in villages with access to all-weather roads and those without access to all-weather roads. For example, according to the result in Table 3, while 14 per cent of households in villages with good road access have used irrigation, the corresponding figure is 12 for households in villages with poor access ($p<0.05$). Though irrigation and access to road might not have a direct and straightforward linkage with access to road, it has sound implication in areas where the topography is rugged. In addition, significant differences were found in mean values of age, years of schooling, land size, family size and number of farm capital between households in villages with good access and poor access.

Table 3: Mean Comparison of the Variables Used in the Efficiency Model by Type of Accessibility

Variables	Obs	Good access	Good access	Difference	P-Value
Age of the head	4350	46.3521	45.2288	1.123	0.0246 **
Years of schooling	4354	2.0788	1.7983	0.281	0.0019 ***
Land size owned (Ha)	4353	2.5044	2.2992	0.205	0.0010 ***
Amount of fertilizer used	4352	63.6673	59.1495	4.518	0.1383
Total labor used in mandays	4354	404.8127	410.047	-5.234	0.637
Access to credit	4354	0.2421	0.2197	0.022	0.1113
Access to irrigation	4353	0.1617	0.1256	0.036	0.0017 ***
Number of oxen owned	4354	1.4988	1.4784	0.02	0.526
Total value of output	4354	5927.90	5344.58	583.3	0.0530 *
No. of farm capital owned	4354	5.3412	4.6599	0.681	0.0000 ***
Family size adult equivalent	4354	4.7825	4.6742	0.108	0.0917 *
Livestock owned in TLU	4354	6.7385	6.714	0.024	0.9103
		*=10%**=5%	***=1%		

The mean comparison test and values of the variables when compared by survey periods are presented in Table 4. Real value of crop production over the two survey periods has shown that the mean value of output grew from 4803.977 ETB in 2011 to 6215.02 ETB in 2013 (p<0.001). The mean value of fertiliser used per household increased from 53.46 kilogram in 2011 to 67.38 kilogram in 2013 (p<0.001). Access to extension which was 33.9 per cent in 2011 increased to 44.9 per cent in 2013. However, years of schooling has relatively remained unchanged during the two production periods with a mean value of 1.8 for both periods. On the contrary, the proportion of households with access to credit has decreased from 26 per cent in 2011 to 18 per cent in 2013 (p<0.01). The area cultivated has slightly increased from 2.1 hectares to 2.5 hectares at household level (p<0.001). On the other hand, farm asset indicators like number of ploughing oxen, number of farm capital and total livestock owned in tropical livestock until (TLU) increased from 1.4 to 1.5, from 4.5 to 5.1 and 6 to 7, respectively (p<0.001).

Table 4: Mean Comparison of the Variables Used in the Efficiency Model by Survey Period

Variables	Obs	2013	2011	Difference	P-value	
Age of the head	4348	46.355	44.7381	1.617	0.0003	***
Years of schooling	4354	1.8911	1.864	0.027	0.7386	
Land size owned (Ha)	4353	2.542	2.1724	0.37	0.00	***
Amount of fertilizer used	4352	67.381	53.464	13.917	0.00	***
Total labor used in mandays	4354	428.106	389.02	39.079	0.0001	***
Access to credit	4354	0.1856	0.2664	-0.081	0.00	***
Access to extension	4354	0.4492	0.3397	0.109	0.00	***
Access to irrigation	4353	0.1406	0.131	0.01	0.356	
Number of oxen owned	4354	1.5425	1.4258	0.117	0.0001	***
Total value of output	4354	6215.02	4803.977	1411.048	0.00	***
No. of farm capital owned	4354	5.1915	4.5136	0.678	0.00	***
Family size in Adult equivalent	4354	4.8723	4.5374	0.335	0.00	***
Livestock owned in TLU	4354	7.1515	6.2903	0.861	0.00	***
*=10%**=5% ***=1%						

The level of total value of output produced is also found significantly varying between the two survey periods. According to the result in Table 4 and the trend line in Figure1, total value of output has increased from 4893 in 2011 to 6215 (p<0.00) and the trend line in Figure 1 shows that this gap is somehow widening. This can be attributed to the increase in the use of conventional inputs like fertiliser.

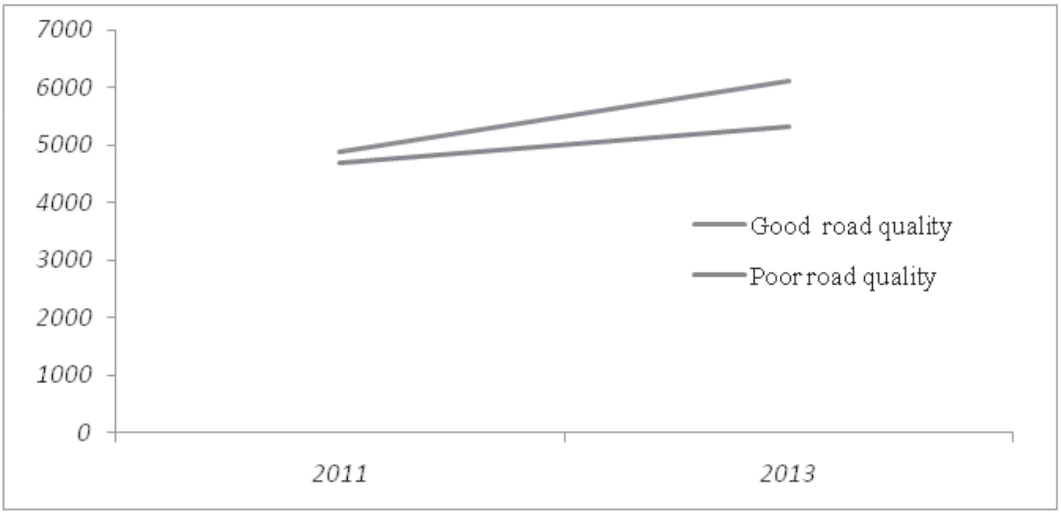


Figure 1: Trend in Mean Value of Output between the Two Periods

As evident from Figure 1, the proportion of households in villages with access to all-weather roads (good access) increased from 658 (30.24 per cent) in 2011 to 671 (30.89 per cent) in 2013. Although this is a small change, the increase in access to all-weather roads might be attributed to the ongoing Universal Road Access Programme (URRAP) which aimed at connecting all Kebeles (smallest administrative unit of Ethiopia) to the nearby all-weather roads, the construction of 11,212 kilometres of new rural roads and the construction of 71523 kilometres of Woreda (third level administrative divisions of Ethiopia) roads until 2015.

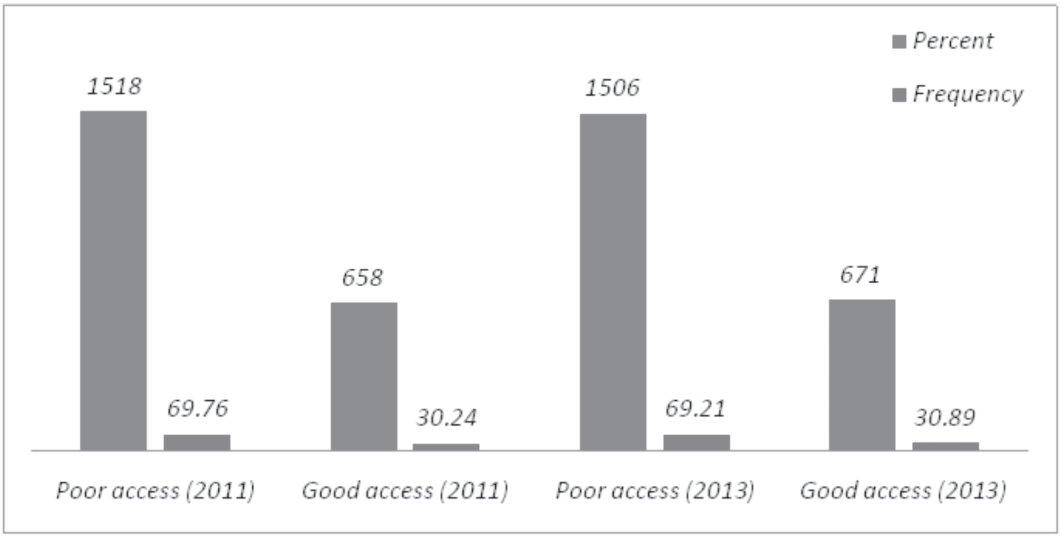


Figure 2: Rural Road Quality Condition from the LSMS Data

On the other hand, the overall distribution of the major mode of transport used for agricultural purposes is presented in Figure 3. The pooled distribution of mode of transport in Figure 3 shows that while 3410 (78 per cent) of them have used foot and 701 (16 per cent) traditional mode of transport, only 241 (5.4 per cent) have used modern mode of transport.

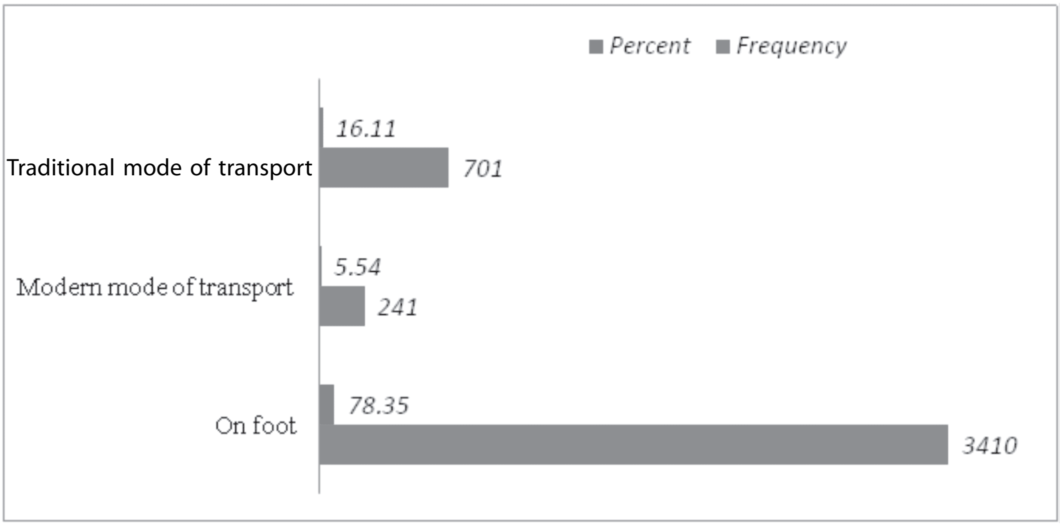


Figure 3: Major Modes of Transport Used for Agriculture-related Activities
Source: Own depiction from the Ethiopian socio-economic survey data.

The comparison of modes of transport used between households in villages with good access and poor access is presented in Table 5 below. The result shows that the proportion of households in villages with poor and good tend to use similar transport facilities for agricultural purposes. In both categories, the dominant mode of transport is foot followed by traditional and modern modes of transport. The implication is that, the level of adoption of both modern and traditional mode of transport is low for both households in villages with good access and poor access. The same Table shows that foot is the dominant mode of transport for both households in villages with good access and poor access. Similarly, the comparison of modes of transport by periods is presented in Table 5 below. The result shows a similar pattern of use of transport facilities for agricultural purposes in both periods. In both periods, the dominant mode of transport is foot followed by traditional and modern modes of transport. The implication is that, the level of adoption of both modern and traditional modes of transport is low in both periods. The same Table shows that foot is the dominant mode of transport in both periods.

Table 5: Mode of Transport, Survey Period and Type of Road Quality

Type of mode	Good access (pooled)	Poor access(pooled)
On foot	1033 (77.79)	2377 (78.6)
Modern mode of transport	78(5.87)	163 (5.39)
Traditional mode of transport	217(16.34)	484(16.01)
Type of mode used	2011	2013
On foot	1841(84.6%)	1569(72.1%)
Modern mode of transport	99(4.55%)	142(6.53%)
Traditional mode of transport	236(10.58%)	465(21.37%)

In order to show the effect of rural accessibility and mobility on agricultural production, a Cobb-Douglas production function with fixed and random effects was estimated. The Hausman test was employed to choose between the fixed and the random effects. The Hausman test result shows that the p-value is just 0.000. Thus, we can conclude that the random effect is rejected in favour of the fixed effects estimation. The details of Hausman test result and results of the fixed and random effects are presented in Appendix: Annexure IV. In addition to the Hausman test, the production model was tested for existence of heteroskedasticity and multicollinearity problems. The heteroskedasticity problem was adjusted by regressing both the fixed and random effect models with robust standard. The multicollinearity problem was checked using the observed information matrix (OIM) during the estimation of the variance –covariance matrix (the result is presented in Appendix: Annexure V. Moreover, group-wise heteroskedasticity was tested using the Wald test statistics (Appendix: Annexure VI). The result revealed that there was no problem of multicollinearity while estimating the production model.

According to the fixed effect result presented in Table 6, most of the parameters were found to be statistically significant in explaining agricultural production. The fixed effect model shows that while amount of labour used in mandays, land size, quantity of fertiliser used, number of oxen used, access to extension, modern and traditional modes of transport have a significant positive effect on production, only access to credit has a significant but negative effect on agricultural crop production. On the other hand, amount of seed used, age, education, sex, access to irrigation and family size found to have an insignificant effect on crop production. This insignificant effect of these variables on crop production can be explained by the findings from the descriptive statistics. For example, the descriptive statistics show that the mean years of schooling is just 1.8 years which is relatively low to impact on agricultural crop production. Other studies have confirmed that such low level of education can hinder the adoption of new techniques of production (Olujenyo, 2005). The descriptive statistics also show that only 12 per cent of the sample households use irrigation for agricultural purposes. This can also be considered small to induce agricultural production growth.

Furthermore, the quantity of seed applied, which was found to have no effect on agricultural crop production, has a mean value of 27 kilogram at household level which further declines to six kilogram when we consider per holder.

The fixed effect estimation shows that a one per cent increase in total labour (mandays) increases crop production by 0.06 per cent[3] ($p<0.00$). The implication is that the increase in use of labour increases agricultural production. This result is consistent with other empirical studies in Ethiopia. For example, both Fantu (2009) and Fantu et al., (2009) using the ERHS longitudinal panel data found that labour has a significant and positive impact on agricultural crop production in Ethiopia. However, according to Fantu et al., (2009), the elasticity of its magnitude is significantly lower than the elasticities for the relatively scarce inputs.

Farm size has a positive and significant effect on agricultural crop production. A one per cent increase in farm size increases crop production by 0.07 per cent ($p<0.00$). This is expected as land is the major prominent factor of agricultural crop production (input) for countries like Ethiopia (Amsalu et al., 2006). Obviously, the quantity of fertiliser used has a positive and significant effect on crop production ($p<0.01$). For example, as the quantity of fertiliser applied increases by one per cent, crop production will increase by 0.06 per cent. The number of ploughing oxen owned was found to be statistically significant at one per cent level of significance. Thus, a one per cent increase in number of oxen owned will increase crop production by 0.17 per cent ($p<0.1$). This is expected as most farmers in Ethiopia depend on traditional technologies for crop production. The ownership of oxen determines the farming ability of farmers because if farmers do not have oxen, they would be obliged to rent out their land to other farmers, which can further reduce agricultural production (Holden et al., 2004).

The provision of extension service found to be statistically significant at 10 per cent level of significance. The result of the fixed effect model shows that for farmers with access to extension service, crop production increased by 30 per cent [4] as compared to those who do not have extension service. This result is also similar to other studies in Ethiopia. For example, Fantu et al., (2009), found that calculated elasticity associated with participation in the extension programme is one of the largest for smallholders in Ethiopia. However, it should be noted that only 35 per cent of the households have access to agricultural credit service. Thus, still there is a need to expand both the quality and coverage of extension service to smallholder producers. On the other hand, unexpected result was found for access to credit. The result shows that farmers with access to credit service produce less output as compared to farmers with no access to credit ($p<0.1$).

The main objective behind estimating the production model is to see the relationship between accessibility, mobility and production. There are two indicators considered to show the effect of rural transport system. While access to all-weather roads was considered as the indicator of road quality or physical accessibility, the main mode of transport used to get to market to buy inputs or to sell agricultural outputs was considered as a proxy variable to measure mobility choice or rural access to transport services or mobility. According to fixed effect result, good road access has a positive but not statistically significant effect on agricultural crop production. This can be further explained that improved road and other infrastructure facilities have an impact on marketability and market access and therefore, on crop production. Thus, if farmers have access to market, then they can easily access agricultural inputs (fertiliser and seed) which are essential to improve crop production and productivity.

From the result, it emerged that crop production is five per cent higher for households in villages with good access as compared to households in villages with poor access. It is important to note that road and other infrastructure investment do need more time to examine their effect on crop production. However, the positive effect of road quality can be associated with indirect effect of rural roads on agricultural production.

On the other hand, the effect of mode of transport was found to be positive and significant determinant of agricultural crop production. The result indicates that expected percentage of increase in geometric mean from foot users group to modern transport users group is about 348 per cent holding other variables constant. By the same token, expected per cent increase in geometric mean from foot users group to traditional transport mode users group is about 145 per cent holding other variables constant. Thus, the mobility effect was found to be more important in explaining agricultural production differential than the road quality. Thus, farmers using traditional and modern mode of transport have produced more output as compared to those who used only walking as mode of transport. This result shows that the mobility effect seems to be larger than the accessibility effect even if the village road quality might not be all-weather road still farmers might use the chance to use better mode of transport services at least during the dry season the effect mobility can be singled out from the road quality. However, it should be clear that the combined effect of road quality and provision of better means of transport would have a greater effect (direct and indirect) on agricultural production.

Table 6: Regression Result

Variables	Fixed Effect	Random Effect
Accessibility indicators (1=yes)	0.0541	0.0231
	(0.0642)	(0.0480)
Type of mode of transport		
Modern mode of transport	1.541***	1.498***
	(0.117)	(0.0889)
Traditional mode of transport	0.987***	0.896***
	(0.0802)	(0.0584)
Logarithm of mandays	0.0658***	0.0960***
	(0.0176)	(0.0132)
Logarithm of land size	0.0801***	0.0906***
	(0.0159)	(0.0117)
Logarithm of fertiliser	0.0652***	0.0518***
	(0.0199)	(0.0120)
Logarithm of seed	-0.00605	-0.0232*
	(0.0177)	(0.0135)
Logarithm of oxen	0.178*	0.167***
	(0.102)	(0.0577)
Age of the head	-0.00144	0.00143
	(0.00708)	(0.00162)
Sex of the head (1=male)	-0.227	0.348***
	(0.211)	(0.0630)
Years of schooling of the head	0.0127	0.0430***
	(0.0119)	(0.00824)
Access to extension (1=yes)	0.277***	0.279***
	(0.0785)	(0.0557)
Access to irrigation (1=yes)	-0.0318	0.186***
	(0.112)	(0.0653)
Year (Hickman neutral)	0.462***	0.497***
	(0.0446)	(0.0412)
Logarithms of farm capital	0.0497	0.227***
	(0.0587)	(0.0374)
Constant	6.199***	5.166***
	(0.370)	(0.146)
Observations	4,344	4,344

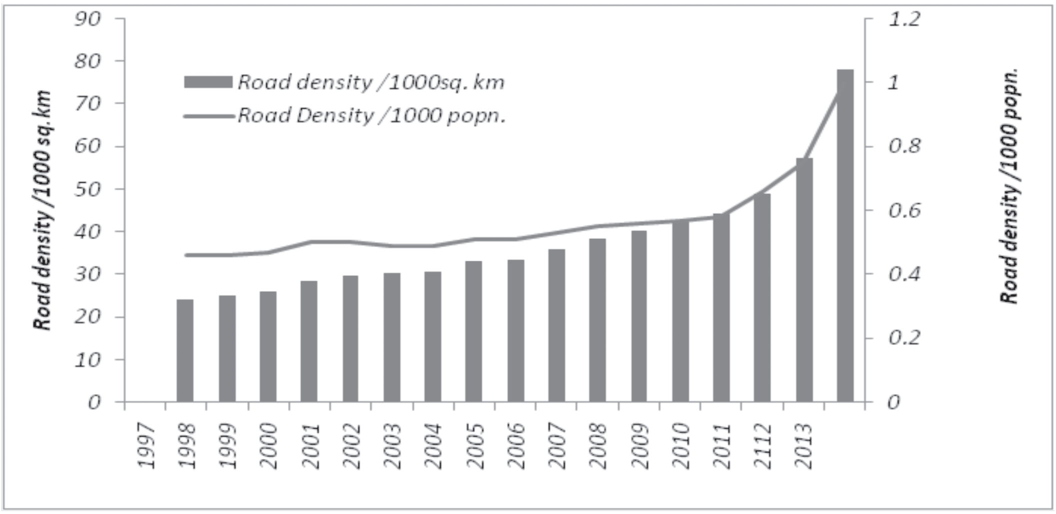
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Conclusion

Rural communities in Ethiopia have different levels of accessibility and mobility as far as access to all-weather roads and use of mode of transport are concerned. There exists low utilisation of modern mode of transport for agriculture-related activities and by far foot is still largely a dominant mode of transport for agricultural purposes. Even though there is an increase in the level of access to all-weather roads, still majority of rural farmers uses foot method as a major means of transport to carry agricultural inputs and outputs to market. Moreover, the study found that heterogeneity in modes of transport used (mobility) can explain the difference in crop production. According to fixed effect result, good road access has a positive but not statistically significant effect on agricultural crop production. From the result, it emerged that crop production is five per cent higher for households in villages with good access as compared to households in villages with poor access. However, it is important to note that road and other infrastructure investment do need more time to examine their effect on crop production. However, the positive effect of road quality can be associated with indirect effect of rural roads on agricultural production. On the other hand, the effect of type of mode of transport was found to be positive and significant determinant of agricultural crop production. The result indicate that expected percentage of increase in geometric mean from foot user group to modern transport users group is about 348 holding other variables constant. By the same token, expected percentage of increase in geometric mean from foot users group to traditional transport mode users group is about 145 holding other variables constant. Thus, the mobility effect was found to be more important in explaining agricultural production differential than the road quality. The implication is even if access to all-weather roads has no effect on technical efficiency, the adoption and continued use of transport facilities (compared to foot) can still be significant. This is probably due to the fact that transport facilities can offset the negative effect of distance on crop production of farmers. The policy implication is improving rural roads to a level of all-weather road standards and provisions of transport facilities for smallholders should still be a priority for policymakers.

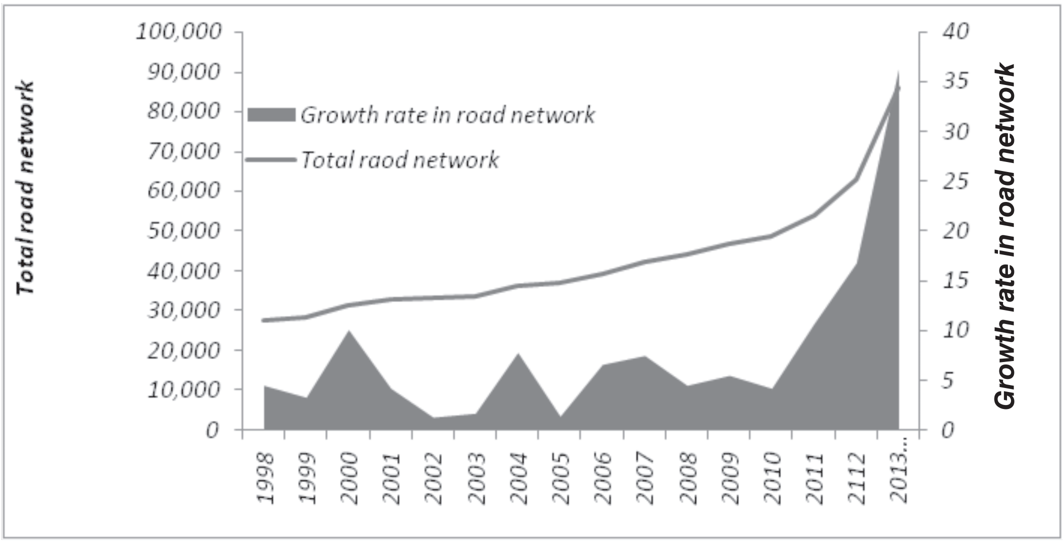
Appendices

Annexure-I



Trends in Road Density/1000 sq.km and Road Density /1000 Population in the Past 20 Years

Annexure-II



Trends in Road Network and Growth Rate in the Past 20 Years

Annexure-III

The Development of Overall Road Infrastructure in Ethiopia in the Past 20 years

Year	Road Network in km					Growth Rate (%)	Road Density / 1000 popn.	Road Density / 1000 sq. km
	Asphalt	Gravel	Rural	Woreda	Total			
1997	3,708	12,162	10,680	Na	26,550		0.46	24.14
1998	3,760	12,240	11,737	Na	27,737	4.5	0.46	25.22
1999	3,812	12,250	12,600	Na	28,662	3.3	0.47	26.06
2000	3,824	12,250	15,480	Na	31,554	10.1	0.5	28.69
2001	3,924	12,467	16,480	Na	32,871	4.2	0.5	29.88
2002	4,053	12,564	16,680	Na	33,297	1.3	0.49	30.27
2003	4,362	12,340	17,154	Na	33,856	1.7	0.49	30.78
2004	4,635	13,905	17,956	Na	36,496	7.8	0.51	33.18
2005	4,972	13,640	18,406	Na	37,018	1.4	0.51	33.6
2006	5,002	14,311	20,164	Na	39,477	6.6	0.53	35.89
2007	5,452	14,628	22,349	Na	42,429	7.5	0.55	38.6
2008	6,066	14,363	23,930	Na	44,359	4.5	0.56	40.3
2009	6,938	14,234	25,640	Na	46,812	5.5	0.57	42.6
2010	7,476	14,373	26,944	Na	48,793	4.2	0.58	44.39
2011	8,295	14,136	30,712	854	53,997	10.7	0.66	49.09
2112	9875	14675	31550	6983	63083	16.8	0.75	57.3
2013	11301	14455	32582	27628	85966	36.3	1	78.2

Annexure-IV

Hausman Fixed and Random Effects

Explanatory	Fixed Effects ((b)	Random Effects (B)	Difference (b-B)	sqrt(diag (V_b-V_B)) S.E.
Accessibility indicator	0.0581412	0.025388	0.0327532	0.0425134
Modern mode of transport	1.538463	1.496128	0.0423353	0.0760621
Traditional mode	0.9784281	0.8932339	0.0851942	0.0548364
Logarithm of mandays	0.0650407	0.0946258	-0.0295851	0.0115903
Logarithm of land size	0.0804381	0.0906418	-0.0102038	0.0106901
Logarithm of fertiliser	0.0653946	0.0517959	0.0135987	0.0158586
Logarithm of oxen	0.1760692	0.1659697	0.0100995	0.0836571
Age of the head	-0.0013651	0.0015437	-0.0029088	0.0068649
Sex of the head	-0.2261772	0.3456541	-0.5718313	0.2002745
Years of schooling	0.0126199	0.0428413	-0.0302214	0.0085148
Access to credit	-0.1153786	-0.1571637	0.0417851	0.0433941
Access to extension	0.2754567	0.2777375	-0.0022809	0.055198
Access to irrigation	-0.0348872	0.1841238	-0.2190111	0.0910611
year	0.4626175	0.4963267	-0.0337092	0.0169946
Logarithm of farm capital	0.0474334	0.2252796	-0.1778462	0.045125

Test: Ho: difference in coefficients not systematic chi2(16) = (b-B)'[(V_b-V_B)^(-1)](b-B = 55.59 Prob>chi2 = 0.0000

Annexure-V

Observed Information Matrix Result (OIM)

e(V)	Access to roads	Modern mode	Traditional mode	Log mandays	Log land size	Log fertiliser	Log arithm of seed	Logoxen	Age	Sex	Education	Extension	Irrigation	Year	Log farm capital	Cons
Access to roads	1															
Modern mode	0.0129	1														
Traditional mode	0.029	0.17	1													
Log mandays	0.0732	0.0192	0.0101	1												
Log land size	-0.048	-0.011	-0.0947	-0.049	1											
Log fertiliser	0.0251	-0.034	-0.0771	-0.052	-0.0626	1										
Log seed	-0.024	0.0073	-0.0186	-0.049	-0.0147	-0.115	1									
Logoxen	0.0262	-0.07	-0.1195	0.0572	-0.0893	-0.081	0.038	1								
Age	-0.025	0.0199	-0.0149	0.0469	-0.0233	0.0163	0.016	-0.029	1							
Sex	0.005	-0.015	-0.0342	-0.059	-0.0205	0.0352	-0.01	-0.052	0.138	1						
Education	-0.036	0.0083	-0.0092	0.0054	0.0028	-0.061	0.006	0.0093	0.098	-0.07	1					
Extension	-0.102	-0.029	-0.0044	0.0349	0.0043	-0.491	-0.06	-0.046	-0.01	-0.04	-0.002	1				
Irrigation	-0.03	0.014	0.0328	-0.015	-0.0133	0.0186	0.009	0.0073	-0.01	-0.04	-0.009	-0.041	1			
Year	-0.004	-0.051	-0.1517	0.2107	0.1349	-0.021	0.014	-0.002	-0.05	0.003	-0.007	-0.075	-0.02	1		
Logfarm capital	-0.035	-0.032	-0.0513	0.0147	-0.0745	-0.089	-0.03	-0.263	-0.09	-0.19	-0.037	-0.019	-0.002	0.02	1	
Cons	-0.088	-0.018	0.0461	-0.57	0.0316	-0.022	-0.17	0.0091	-0.53	-0.31	-0.101	0.029	-0.025	-0.5	-0.185	1

Annexure-VI

Modified Wald test for groupwise heteroskedasticity in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (2177) = 5.1e+35

Prob>chi2 = 0.0000

Notes

1 Detailed sampling procedure can be referred from the ESS-LSMS report.

2 We considered value of production than volume of production.

3 If both the dependent and independent variables are log-transformed, then we can use $[(1.01^{B_1}-1)]*100$, if the coefficient is less than 10, $[(1.01^{B_1}-1)]*100$ can be approximated by B_1.

4 For log dependent variable and dummy independent and continuous independent variables, one can use $100*(e^{B_1}-1)$ where B_1 is a coefficient. For example, expected increase of percentage in geometric mean from no access to extension group to extension access to group is about 30 per cent holding other variables, since $100*(e^{0.275}-1)=30$ per cent.

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