Public Investment on Rural Road Transport and Its Effect on Total Factor Productivity: Evidence from the Ethiopian Living Standard Measurement Survey

Naod Mekonen and ***Bamlaku Alamirew***[**]

Abstract

Given that 83 percent of the Ethiopian population live in rural areas being engaged in agriculture, the role of rural road transport in Ethiopia in improving rural livelihoods and agricultural growth is expected to be tremendous. However, empirical studies on the effect of rural road transport (access and mobility) on total factor productivity are scant. This study intends to fill this gap by using the Malmquist index to measure total factor productivity indices of each farmer by decomposing its two components: technical efficiency change index and technological change. In order to estimate the effect of heterogeneity in rural transport on total factor productivity change in a panel data setting, fixed and random effect models were estimated. Hausman test was applied to choose one of them. Data emerged from two consecutive panel surveys of the Ethiopian Rural Socioeconomic Survey (ESS) –Living Standard Measurement Survey (LSMS). Finally, a balanced panel of 2176 households consisting of 4352 observations over two rounds was created. Results show that the change in total factor productivity is attributed largely to technological change when compared to technical change. On the other hand, the result shows that mean efficiency change of households with access to all weather roads is higher than that of households with no access to all weather roads. Findings suggest that investing in roads is vital to help move agriculture forward.

Keywords: total factor productivity, Malmquist index, panel data, Ethiopia

1. Introduction

Road transport is an important transport system in Ethiopia. This is evident as road transport is the dominant form of transport accounting for 90 to 95 percent of motorized inter-urban-rural freight and passenger movements (ERA, 2013). The role of road transport in Ethiopia emanates from the fact that the country is landlocked and there are only few navigable rivers that can serve both domestic and international transport services (Admasu *et al.*, 2012). Nevertheless, the level of road transport infrastructure in the country

[**] Associate Professor of Development Economics, e-mail: bamlakalamirew@gmail.com

has been generally low. For example, while road density per 1000 sq.km and per 1000 population is 78 kms and 1km, respectively, the total road network of the country is 85,966 km constituting 11301 kms of Asphalt (15 percent of the road network), 14455 kms of Gravel road, 32582 kms of rural roads and 27628 kms of Woreda roads (Appendix: Annex I). This is relatively very small compared to the 1.1 million square kilometer area and population size of more than 118 million in 2020. However, it should also be noted that the growth in road network has been impressive in the past twenty years. For example, while the total rural road network has increased from 10680kms in 1997 to 32582 kms in 2013, the total road network has increased from 26550kms in 1997 to 85966 kms in 2013 with an annual average growth rate of 7.9 percent (Appendix: Annex I).

Ethiopia has made relatively massive investment on the development of roads to tackle isolation and improve the welfare of the rural poor. For example, according to ERA reports, the overall disbursement over the past 17 years (1997- 2014) of Road Sector Development Plan is about Birr 180.9 billion (USD 12.2 billion). Moreover, since the launching of RSDPs, the issue of access to roads has been linked with the country's development policies and strategies. Particularly, the various sectoral and multi-sectoral policies and strategies of the government of Ethiopia (GoE) have emphasized that access to all weather roads had remained the important unmet demand in rural areas. In this regard, the recent five-year Growth and Transformation Plan (GTP) extending over the period 2010/11 to 2014/15, the government of Ethiopia (GoE) formulated and forward envisages to connect kebeles, the smallest administrative units in Ethiopia, to all-weather roads, the construction of 11,212 kms of new rural roads and the construction of 71523 kms of Woreda roads under its Universal Rural Road Access Program (MoFED, 2010).

The role of rural road transport in Ethiopia in improving rural livelihoods and agricultural growth is expected to be tremendous. This is so because, in the country about 83 percent of the population lives in rural areas being engaged in agriculture (which employees 80 percent of the labour force) and using road transport (which accounts 90 percent of rural transport) (CSA, 2013; ERA, 2013). However, despite such investment rural road development indicators show that the country's rural road transport has still remained low. For example, while the proportion of area further than 5 kms from all-weather roads is 40.5 percent, the average distance to all-weather roads is 6 kms (ERA, 2014). As a result, close to 70 percent of the rural population in Ethiopia still need to travel about six hours to reach all weather roads, and to make things worse, most rural roads are dry weather roads that cannot be passable by any formal transport modes during the wet season (Wondemu, 2015). Interestingly, while the average RAI for the country is around 50 percent (ERA, 2014), the proportion of rural population within 2kms access is only 28.8 per cent, very small compared to the size of 90 million people in rural areas of the country. Furthermore, reports also indicate that the level of rural mobility is also low by any measure and rural communities mainly rely upon pack animals and carrying loads on their own heads and backs to get goods to market and home (ERA, 2011; Arethun and Bhatta, 2012).

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; Wondemu *et al.*, 2012; Decron *et al.*, 2009; Lulit, 2012; Wondemu, 2015). However, less has been studied about the effect of rural road transport (access and mobility) on total factor productivity. Thus, this study intends to fill this knowledge gap by analysing the impact of rural road transport (accessibility and mobility) on total factor productivity. Above all, it is imperative to look at this issue as the country has envisioned to connect kebeles to all weather roads so as to improve agricultural productivity thereby improving welfare of the economy and transform the rural economy.

2. Data

The empirical data were drawn from two consecutive panel surveys of the Ethiopian Rural Socioeconomic Survey (ESS) Living Standard Measurement Survey (LSMS). The data were collected by the Central Statistics Agency (CSA) and the World Bank. The first-round survey was conducted in 2011 and the second wave was conducted after two years in 2013. In agriculture and rural transport, middle towns and small-town were excluded from the sample. The panel data was 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.

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 into 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 expenditure was calculated. Second, the food and non-food expenditure was converted into 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 quantity reported in grams were converted into kilogram values. The quantity of production (crop and root crops or fruits) was converted into value in value in 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 household who did not report any crop sell in the market, the mean village level price of each crop was used to convert quantity of production in to value of production.

Finally, the nominal value of production was converted into 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 using Janke (1982) approach.

Another important issue is a 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 if community/village roads in their respective villages. Following Dercon, *et al*. 2009; Wondemu and Weissb, 2012), the road quality of the villages is categorized into two groups. The first one is 'good road access' that indicate access to all weather roads. The second one is 'poor road access' and it represents roads that do not allow reasonable access through 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 agricultural related activities. In this regard, foot, traditional mode of transport (such as pack animals, animal drawn carts, and one-wheeled cart) and modern mode of transport (such as Bajaj, motor cycle, cycle, and mini-bus).

3. Method of Data Analysis

The theoretical and empirical literature show that partial and total factor productivity measures are the two key measures of agricultural productivity depending on the number of inputs considered (Urgessa, 2015). Partial productivity measures the contribution of one factor (say labour or land) to output growth keeping the other factors constant (Saikia, 2014). However, there are at least two weaknesses of partial productivity measures: these are: 1) partial productivity does not indicate whether productivity growth is because of more use of inputs or improvement in the efficiency of their use or technology improvement (Saikia, 2014); and 2) partial measures of productivity index do not account for all the inputs used in production process (Urgessa, 2015). On the other hand, there are also strong points when using partial productivity measures. For example, in most developing countries like Africa where formal markets are absent and prices of inputs are missed, using measures of partial productivity indices would give advantages over total factor productivity (Kelly, 1995).

Total factor productivity (TFP) measure the net growth of output per unit of total inputs, which means that total factor productivity is the productivity when all factors are taken in the determination of productivity (Kabwe, 2012). Total factor productivity (TFP) is considered as the better productivity measure than the partial productivity measure in that the more input considered the better is the productivity measure in terms of representation of productivity. Thus, the best measure is the one that evaluates the level of a given output with the combined use of all inputs (Chandel, 2007 in Saikia, 2014). There are two TFP indices commonly used in empirical studies to estimate total factor productivity, namely the Malmquist and the Törnqvist index (Saikia 2014). However, the choice between these two indexes matters little and can thus be left to the individual researcher (OECD, 2001). Thus, this study used the Malmquist index to measure the total factor productivity indices of each farmer and following Coelli *et al.*, (2005); Tadesse (2007) and Ayele *et al*, (2006). The Malmquist TFP index has two elements: these are technical efficiency change index and technological change index. The technical efficiency change index $(TEI_{i(t+1)})$ is the ration of two technical efficiency distance functions for *t+1* and *t* periods for i^{th} household or farmer, and it can easily be obtained from the previous equation given by ;

$$TE = \frac{y_{it}*}{y_{it}} = \frac{exp(\gamma_{ti}\theta + T_{it} - R_i t)}{exp(\gamma_{it}\theta + T_{it})} = e^{-u_{it}} \qquad (7)$$

and has the following functional expression;

$$TEI_{i(t+1)} = \frac{TE_{i(t+1)}}{TE_{it}} . \qquad (8)$$

Where $y_{it}*$ is the actual production at the time t (t = 1,2,..., T) for the i^{th} households;

y_{it} is the potential production at the time t (t =1,2,..., T) for the i^{th} household.

On the other hand, the technological change index (TCI) between two consecutive years t*+1* and *t*, for household *i*, can be obtained from the estimated parameters of the stochastic production frontier. According to (Ayele *et al,* 2007), the average measaure of technological change can be extracted from the first derivatve of the estimated function with respect to time *t* at mean values of input used in each year.

This gives: $\frac{\partial \mathrm{Ln}[\mathrm{E}(\mathrm{Y}_{it})]}{\partial \mathrm{t}_t} = \beta_t + 2\beta\beta_t + \sum_j^n \beta_{it} X_i$

and according to (Coelli, *et al* 1996 in Ayele *et al*, 2006) by applying the geometric mean on the dervated equation above gives the technological change for the two adjacent periods :

$$TCI_{i(t+1)} = \sqrt{\left\{1 + \frac{\partial f\left(x_{i(t+1)}(t+1),\beta\right)}{\partial(t+1)}\right\}\left\{1 + \frac{\partial f\left(x_{i(t+1)}(t+1),\beta\right)}{\partial t}\right\}} \quad (9)$$

Finally, according to Coelli *et al*, (1998) the product of total technical change and total technological change given by;

$$TFP_{it} = TEI_{it} \times TCI_{it} \quad (10)$$

After estimating the total factor productivity for each household using the Malmquest index the next step was to identify the effect of accessibility, mobility and other covariates on total factor productivity. Total factor productivity can be approximated with a linear function of the explanatory variables or factors (Key and McBride, 2003). These factors on the other hand, can be fitted by the OLS method but using diverse econometric specifications, namely, the Cobb-Douglas, semi-log, quadratic and the exponential functional forms, the log linear model is selected to be the best fit and the estimable form of the model is specified as:

$$\mathrm{TFP}_{it} = \alpha_0 + \alpha_1 age_{it} + \alpha_2 edu_{it} + \alpha_3 logfami_{it} + \alpha_4 ext_{it} + \alpha_5 logoxen_{it} + \alpha_6 raodacce_{it} + \alpha_7 raodacc * time_{cit} + \alpha_8 irrg_{it} + \alpha_9 logmandays_{it} + \alpha_{10} transpmX_{it} + \varepsilon \quad (11)$$

Table.1. Description of variables used in the analysis of total factor productivity

Variables	Descriptions the variables	Exp. sign
TFP_{it}	total factor productivity for household *i* at time *t*	
age_{it}	number of farm asset or capital for household *i* at time *t*	+
edu_{it}	years of schooling of the head of i^{th} household *i* *at time t*	+, -
$logfami_{it}$	logarithm of family size for household *i* at time *t*	-or +
ext_{it}	access to extension *i* at time *t*	+
$logoxen_{it}$	logarithm of oxen owned by i^{th} household at time *t*	+
$raodacc_{it}$	access to road for the i^{th} household at time *t*	+
time	Survey period considered	+
$raodacc_{it}*time$	road access* time for household *i* at time *t*	+
$irri_{it}$	use of Irrigation for agricultural production	+
$logmandays_{it}$	Logarithm of total labour used by household *i* at time *t*	- or +
Logferti	logarithm of quantity of fertilizer	+
$transpm_{it}$	mode of transport used by the i^{th} household at time *t*	+

Source: Compiled from various empirical literatures

4. Results

As evident from Figure 1, the proportion of households in villages with access to all weather roads (good access) increased from 658 (30.24 percent) in 2011 to 671 (30.89 percent) 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 program (URRAP) which aimed at connecting all Kebeles to the nearby all-weather roads, the construction of 11,212 kilometres of new rural roads and the construction of 71523 kilometres of woreda roads until 2015.

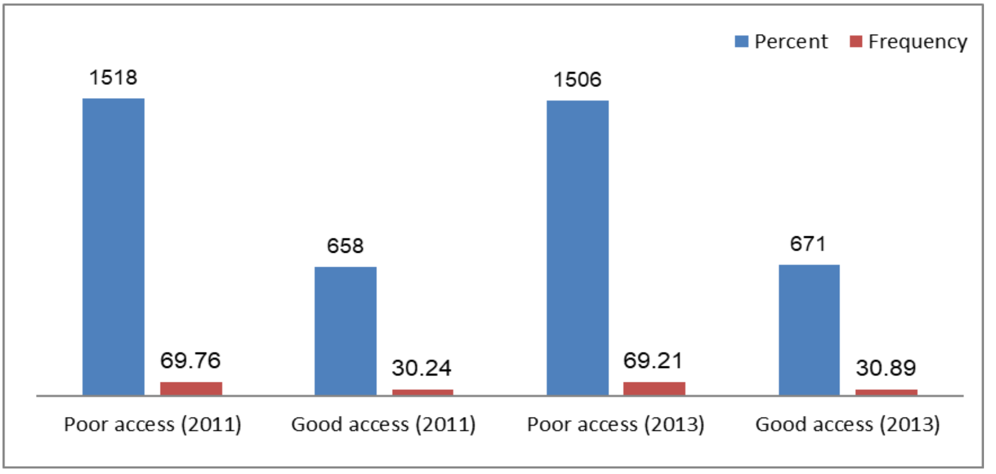

Figure 1. Rural road quality condition from the LSMA data

On the other hand, the overall distribution of the major mode of transport used for agricultural purposes is presented in Figure 2. The pooled data shows that while 3410 (78%) of them have used foot and 701 (16%) traditional mode of transport only 241 (5.4%) have used modern mode of transport.

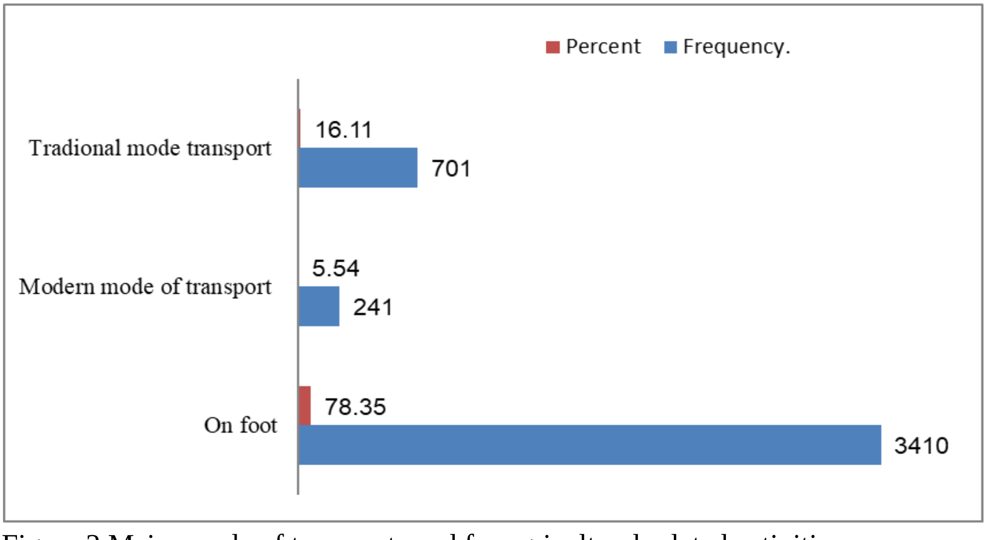

Figure.2 Major mode of transport used for agricultural related activities
Source: Own depiction from the Ethiopian Socio-economic survey data

The comparison of mode of transport used between households in villages with good access and households in villages with poor access is presented in Table 2. The result shows that the proportion of households in villages with poor and good access tend to use similar transport facilitates for agricultural purposes. In both categories, the dominant mode of transport was foot followed by traditional and modern mode of transport. The implication is that, the level of adoption of both modern and traditional mode of transport was low for both households in villages with good access and poor access. The same Table shows that foot is the dominant mode of transport both for households in villages with good access and poor access.

Table 2. Comparison of households based on mode of transport and 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)

Similarly, the comparison of mode of transport by periods is presented in Table 3 below. The result shows a similar pattern of use of transport facilitates for agricultural purposes in both periods. In both periods, the dominant mode of transport is foot followed by traditional and modern mode of transport. The implication is that, the level of adoption of both modern and traditional mode of transport is low both in both periods. The same The data in Table 3 shows that foot is the dominant mode of transport in both periods.

Table 3. Type of mode of transport used when compared by the two periods

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%)

The data used for TFP analysis is presented here. Since TFP analysis avoids missing values, any missing observation either in inputs or outputs side were excluded from the analysis, which reduced the number of observations. The mean comparison of covariates used to explain real consumption per capita and total factor productivity are presented in Table 4. The ratio of land to family labour has decreased from 0.63 in 2011 to 0.59 in 2013 ($p<0.05$). Family economic burden is measured in terms of decency ratio, according to the mean comparisons result, dependency ration has increased from 0.069 in 2011 to 0.73 in 21013 (p<0.1). The mean age of the head has slightly increased from 44.7 in 32011 to 46.3 in 2013 (p<0.001). On the other hand, the, the mean level of access to credit which is indicator of accessibility finance to farmers has decreased from 25 % in 2011 to 18 % in 2013 (p<0.00). The number of oxen owned measured in tropical livestock units has increased from 6.3 units in 2011 to 7 units in 2013 (p<0.00). The same Table also show that while logarithm of agricultural yield has increased from 6.8 in 2011 to 7.1 in 2013 (p<0.00), family size in adult equivalent which is a proxy for family labour has increased from 4.5 in 2011 to 4.8 in 2013 (p<0.00).

Table 4. Mean comparison of covariates used for the real consumption per capita model

Explanatory Variable	2013	2011	Difference	P-Value	
Land to family labour ratio	0.5924	0.6316	-0.039	0.0334	**
Dependency ratio	0.7329	0.6987	0.034	0.0767	*
Participation in off farm income	0.2472	0.2578	-0.011	0.4224	
Sex of the head	0.8111	0.8226	-0.011	0.3273	
Age of the head	46.3625	44.7499	1.613	0.0003	***
Head’s years of schooling	1.8888	1.8617	0.027	0.7384	
Access to credit	0.1788	0.2597	-0.081	0.000	***
Access to irrigation	0.1443	0.1553	-0.011	0.3081	
Road quality	0.3079	0.3024	0.006	0.6929	
Livestock owned (TLUs)	7.1992	6.3639	0.835	0.000	***
Logarithm of agricultural yield	7.9254	6.8532	1.072	0.000	***
Family size in Adult equivalent	4.8731	4.5382	0.335	0.000	***

Level of significance *10% ; **5% ; ***1%

Source: Own depiction from the Ethiopian Socio-economic survey data

On the other hand, a mean comparison of the key covariates of real consumption per capita by the type of road quality is presented in Table 5 below. The mean comparison test result show that there was significant difference between households in villages with good access to all weather roads and households in villages that lack access to all weather roads at least for some of the covariates of real consumption per capita. For example, while the mean values of real consumption per capita ETB 173 birr for households in villages with good access to all weather roads, the mean values of real consumption per capita ETB 173 birr for households in villages with good access to all weather roads ($p<0.00$). The heads mean years of schoolings for households in villages with good access to all weather roads is 2.11 while it was just 1.77 for households in villages that lack access to all weather roads. A significant variation is also observed in the level of access to irrigation. Finally, the mean comparison test for land to family labour ratio show that while the means for households in villages with good access is 0.66 the mean value of land to family labour ratio for households in villages that lack access to all weather roads ($p<0.00$).

Table 5. Mean Comparison of Variables used in Total Factor Productivity

Explanatory variables	Good access	Poor access	Difference	p-value
Real consumption per capita	173.7248	113.39	60.33	0.00
Land to family labour ratio	0.6662	0.5882	0.078	0.00
Dependency ratio	0.6865	0.7287	-0.042	0.04
Participation in off-farm income	0.2688	0.2454	0.023	0.10
Sex of the head	0.8148	0.8178	-0.003	0.81
Age of the head	45.9683	45.3746	0.594	0.22
Head’s years of schooling	2.1145	1.7702	0.34	0.00
Access to credit	0.2154	0.2209	-0.006	0.68
Access to irrigation	0.2319	0.1138	0.118	0.00
Oxen ownerships (TLUs)	6.5791	6.8704	-0.291	0.17
Logarithm of agricultural yield	7.3615	7.4016	-0.04	0.60
Family size in adult equivalent	4.6409	4.7341	-0.093	0.14

Level of significance *=10%**=5% ***=1%

Accessibility and mobility vs. total factor productivity

As discussed in the methodology section, the Malmquist TFP index gives a measure of productivity growth by comparing two data points (periods 1 and 2) in which there are observed inputs and outputs. This TFP index measures productivity by comparing the observed outputs in periods 1 and 2 with the maximum level of outputs that can be produced using the inputs x1 and x^2 under a reference technology. The Malmquist index makes use of a radial distance of the observed outputs and inputs in the two periods with respect to a reference technology (Fulginiti, *et al*, 2004). The distance measure could either be input orientated or output orientated, such that the index depends on the orientation used. This study made use of the input orientated Malmquist TFP index.

Two types of productivity measures are used. These are partial and multifactor indexes. Partial productivity indexes relate output to a single input, such as labour or land. These measures are useful for indicating factor-saving biases in technical change but are likely to overstate the overall improvement in efficiency because they do not account for changes in other input use. For example, rising output per worker may follow from additions to the capital stock, and higher crop yield may be due to greater application of fertilizer. For this reason, a measure of TFP relating output to all of the inputs used in production (Ogundele and Okoruwa, 2014). In this regard, six basic and intermediate inputs used by the respective households were also included while estimating total factor productivity activity. This includes; family labour, seed, fertilizer, number of farm capital owned, number of oxen owned for ploughing, and land. The input orientated Malmquist TFP index was estimated using the software DEA version 2.1 developed by Coelli (1996).

The geometric means of total factor productivity (TFP) growth decomposition are reported in Table 6. According to the information provided in Table 6, there was a positive growth in productivity between the two periods with a value of 1.17, suggesting that relative to period one which is the base year (2011) productivity improved in period two (2013). There are four major sources of total productivity growth the literature, these are – technical change, efficiency change, scale efficiency change and input (or output) mix effect. The Table shows that beside the scale efficiency, all other factors where above unity (1), suggesting that relative to period 1 farmers in period two where more efficient. This change in total factor productivity can be divided in to technical change and technological change. The result also shows that the geometric means of technical and technological change were found to be 1.035 and 1.13, respectively.

This result shows that the change in total factor productivity is attributed largely to technological change when compared technical change. The result indicates that farmers are doing better at both efficiency and technical wise. However, still more can be done and farmers can utilize the existing technology and achieve better yields.

Table 6. Geometric mean of total factor productivity

Variable	**2011 (=100)**	**2013**
Total factor productivity change	1.00	1.170
Efficiency change	1.00	1.035
Technological change	1.00	1.136

Source: Own estimation from the Ethiopian socio-economic survey data

The results from total factor productivity estimation were also compared by the type of village accessibility that a household resides. According to Table 7, even though the mean total factor productivity change was found to be higher for households in villages with good access, the result was not statistically significant (p>0.01). On the other hand, the result shows that while mean efficiency change of households with access to all weather roads is a higher than the mean efficiency change of households with no access to all weather roads, the result of technological change was the inverse of the above. However, the mean comparison test result shows that the result w not statistically significant for both of the comparisons.

Table 7. Geometric mean comparisons by type of rural road accessibility

	Access			
Variable	**Good**	**Poor**	**Diff.**	**P-Value**
TFP change	1.3881	1.3441	0.044	0.2748
Efficiency change	1.2254	1.1824	0.043	0.2246
Technological change	1.1354	1.1391	-0.004	0.2541

Source: Own depiction from the Ethiopian socio-economic survey data

The next step is to see the interaction between total factor productivity change (TFPCH) and accessibility, mobility and other covariates. As discussed in the methodology part, log linear OLS specification was used where some predictor variables were log-transformed. But the outcome variable is in its original scale to analyse the effects of various covariates on the TFPCH. This method is selected from other specifications mainly due to its advantages when some of the observations have a unit values. The Cobb–

Douglas and exponential forms of the model will change the values of the observation of the dependent variables to zero when the dependent variable is changed in to their logarithmic form. On the other hand, before the estimation of the model, a value of unity was assigned for the base year (2011) so as to estimate the model in its panel form. Thus, by definition for the base year (2011) a value one was assigned. Thus, in the second period (2013) while a value of TFP greater than one indicates an increase in TFP, a value of less than one would mean a decrease in total factor productivity.

In order to estimate the effect of heterogeneity in rural transport on total factor productivity change in a panel stetting, fixed and random effect models were estimated. In order to choose between the two alterative panel models a Hausman test is applied. According to the result presented in (Appendix: Annex IV), the Hausman test result shows that the p-value is 0.000 which is less than 0.01. Thus, the null hypothesis that difference in the coefficients is not systematic is rejected. From this, one can conclude that the random effect is rejected while the fixed effect is accepted. Moreover, existence of heteroskedasticity and multicollinearity problems in the fixed model was also tested. The heteroskedasticity problem was adjusted by regressing the estimated models with robust standard (Table 8). The multicollinearity problem was also checked and tested using the observed information matrix (OIM) during the estimation of the variance–covariance matrix. The group wise Heteroskedasticity problem was also checked by using Wald test statistics. The result of the diagnostic test shows that there is no problem of multicollinearity problem during the estimation for the determinants of total factor productivity (Appendix: Annex V)

The result in Table 8 shows the estimation from the linear-log model with its fixed and random effects. As the Hausman test result indicated, the fixed effect model is the appropriate model that represents best estimation. Thus, the discussion here is based on the results of the fixed model. The coefficients of age and years of schooling of the head were found to be positive and insignificant. Thus, age and years of schooling have a positive effect on total factor productivity change but the effect is not statistically significant. As far as the insignificant effect of years of schooling is concerned, the possible explanation could be found from the descriptive statistics. According to the descriptive statistics, the mean value for years of schooling of the head was found to be 1.8 years, which is of course relatively very small. On the other hand, the expected mean difference in total factor productivity scores between households with extension access and households without extension access is about 0.22 units, holding the other predictor variables constant ($p<0.01$). On the other hand, a similar result was also found in other empirical studies. For example, (Fantu *et al*, 2015) found that access to extension has a positive and significant effect on total factor productivity.

On the other hand, due to the log transformation, the estimated effects of logarithm of family size, logarithm of farm size, and logarithm of man-days are no longer linear, even though the effect of logarithm of family size, logarithm of farm size and logarithm of man-days are linear.[1] The coefficient logarithm of family size which was proxy for family labour is found to be positive and significant ($p<0.05$). This result is similar to other empirical studies (Akpan *et al.,* 2011;) also found the same result. The coefficient logarithm of farm size is found to be positive and significant ($p<0.05$). The result from other empirical studies shows that the effect of farm size on total factor productivity is somehow mixed. For example, Bamidele *et al.,* (2008) found a positive and significant effect of farm size on total factor productivity of smallholders in Nigeria. On the other hand, Ukoha *et al.*, (2010) found that farm size is negtively related to total factor prodactivity. In another study, Rachmina *et al.*, (2014), found that farm size has a significant and positive effect on total factor productivity but with low elasticity the coefficient of fertiliser was found to be positive and significant.

On the other hand, the result of the estimation revealed unexpected result for labour in man-days available. The coefficient of labour in man-days available was found to be negative and significant ($p<0.01$). In this regard, few studies have also found similar results for labour in man-days available. For example, Adam *et al*, (2009) aslo reported the existance of such negtaive relationship between labour in mandays and total factor prodacvitiy of smallhllders farmers in Ethiopia. The main reason could be due to the under emplyment problem casued by capacity limitation in terms of access to physcial and financial capital (Adam *et al*, 2009). The implicaiton is that households spending time on non farm or off fram tend have lower prodactive probably due to time constraints to agricltural activities (Shively and Fisher, 2004 in Adam *et al*, (2009).

As evident in Table 8, the effect of road quality was found to be negative and significant ($p<0.01$). The expected mean difference in total factor productivity scores between households with access to all weather roads and households without access to all weather roads was about -0.43 units, holding the other predictor variables constant ($p<0.01$). However, the result of the model also shows that road quality has a positive and significant effect on total factor productivity when one considers the interaction with respect to time.

In this regard, the coefficient of interaction with time shows that the expected mean difference in total factor productivity scores between households with access to all weather roads and households without access to all weather roads is about 0.28 units, holding other predictor variables constant ($p<0.01$). The findings from other empirical studies have a mixed result. Generally, change in infrastructure influence cultivated area and productivity. For example, Rachmina *et al.*, (2014) found that increase of supporting infrastructure (like roads and irrigation) -given fixed output price- will increase cultivated area and total factor productivity that eventually will increase production and profit. However, infrastructure index like irrigation and road access infrastructure were found to have weak positive effect (Rachmina *et al.*, 2014).

Table 8. Regression result for total factor productivity

Explanatory Variables	Fixed effect	Random effect
Age of the head	0.000828	-0.000654
	(0.00330)	(0.000631)
Years of schooling of the head	0.00541	0.00485
	(0.00566)	(0.00352)
Logarithm of family size	0.167**	0.0246
	(0.0817)	(0.0206)
Extension contact (=1)	0.224***	0.184***
	(0.0366)	(0.0232)
Logarithm of oxen	0.244***	0.218***
	(0.0290)	(0.0225)
Road quality (=1)	-0.432***	-0.306***
	(0.023)	(0.012)
Time	0.309***	0.012
	(0.0853)	(0.0620)
Road quality *time	0.280***	0.208***
	(0.0527)	(0.0386)
Logarithm of farm size	0.0258***	0.0144***
	(0.00758)	(0.00498)
Irrigation access (=1)	0.0123	0.00643
	(0.0537)	(0.0273)
Logarithm of mandays	-0.0257***	-0.0176***
	(0.00816)	(0.00563)
Logarithm of fertilizer	0.00409	-0.0206***
	(0.0105)	(0.00550)
Modern mode of transport	0.00721	0.0477
	(0.0559)	(0.0385)
Traditional model of transport	0.0301	-0.00445
	(0.0379)	(0.0249)
Constant	0.787***	1.101***
	(0.201)	(0.0531)
Observations	4,325	4,325
R-squared	0.163	

NB: robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Own estimation from the Ethiopian socio-economic survey data

5. Conclusions

Rural communities in Ethiopia have different level of accessibility and mobility as far as access to all weather roads and use of mode of transport are concerned. There exists low utilization of modern mode of transport for agricultural related activities and by far foot is still largely dominant mode of transport for agricultural purposes. Even though there is an increase in the level access to all weather roads, still majority of rural farmers use foot a major means of transport to transport agricultural inputs and outputs to market. Moreover, the study found that heterogeneity in rural accessibility and mobility can explain difference in total factor productivity.

From the analysis, it emerged that the application and adoption of modern inputs, such as seed and fertilizer in Ethiopia remains very low. The fact that in villages that have good road access, the rate of fertilizer application is high suggests that improving rural roads to a level of all-weather roads standards should be a priority for policy makers. Moreover, households in villages with good access were found to have better access to extension, credit and irrigation as compared to households in villages with poor access.

The result of the total factor productivity analysis shows that access to all weather roads improves total factor productivity with time and it is statistically significant. Otherwise, the result revealed that the effect is negative and significant without interaction with time. The main implication here is that the benefits of roads in improving total factor productivity of farmers might not be seen right after investment on rural roads.

Notes

[1]By definition, one percentage in the independent variable is associated with $B_i \ln(1.01)$ change in the independent variable.

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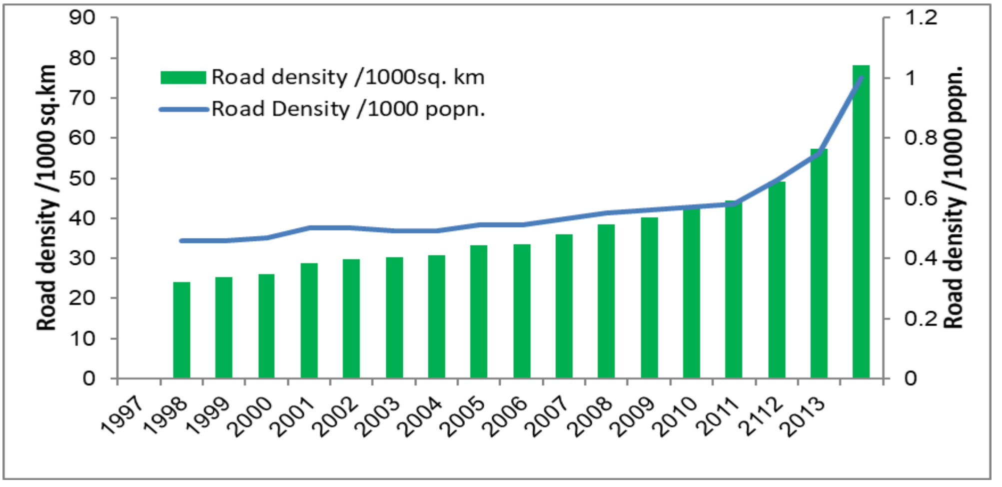
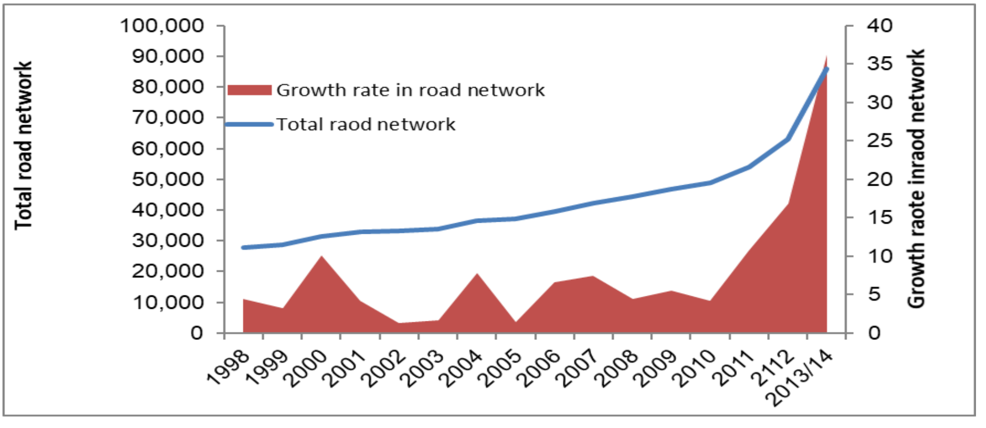
Appendices

Annex I. Trends in road density/1000 sq.km and road density /1000 population in the past 20 years



Annex II. Trends in road network and growth rate in the past 20 years



Annex III. The development of overall road infrastructure in Ethiopia in the past 20 years

	Road network in km					**Growth**	**Road Density**	**Road density**
Year	Asphalt	Gravel	Rural	Woreda	Total	**Rate (%)**	**/1000 popn.**	**/1000sq. km**
1997	3,708	12,162	10,680	-	26,550		0.46	24.14
1998	3,760	12,240	11,737	-	27,737	4.5	0.46	25.22
1999	3,812	12,250	12,600	-	28,662	3.3	0.47	26.06
2000	3,824	12,250	15,480	-	31,554	10.1	0.5	28.69
2001	3,924	12,467	16,480	-	32,871	4.2	0.5	29.88
2002	4,053	12,564	16,680	-	33,297	1.3	0.49	30.27
2003	4,362	12,340	17,154	-	33,856	1.7	0.49	30.78
2004	4,635	13,905	17,956	-	36,496	7.8	0.51	33.18
2005	4,972	13,640	18,406	-	37,018	1.4	0.51	33.6
2006	5,002	14,311	20,164	-	39,477	6.6	0.53	35.89
2007	5,452	14,628	22,349	-	42,429	7.5	0.55	38.6
2008	6,066	14,363	23,930	-	44,359	4.5	0.56	40.3
2009	6,938	14,234	25,640	-	46,812	5.5	0.57	42.6
2010	7,476	14,373	26,944	-	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

Annex IV: Hausman test result for fixed and random effect model

Variables	b(tfp1)	B(tfp2)	Difference	sqrt(diag(b_B))S.E.
Age	0.000828	-0.00065	0.001481	0.0032415
Years of schooling	0.005407	0.004845	0.000561	0.0044358
Log family size	0.166712	0.024618	0.142094	0.0790855
Extension contact	0.223815	0.184396	0.039419	0.0282161
Log oxen	0.243726	0.218466	0.02526	0.0182501
Road access	-0.49189	-0.30558	-0.18631	0.0585032
Road quality* time	0.279626	0.208336	0.07129	0.0358275
Log and size	0.025812	0.014373	0.011439	0.0057139
Irrigation access	0.012339	0.00643	0.005909	0.0462328
Lnmandays	-0.02571	-0.0176	-0.00811	0.0059088
Log fertilizer	0.004088	-0.02059	0.024676	0.0089335
Modern mode	-0.00721	-0.0477	0.040491	0.0404301
Traditional mode	0.030094	-0.00445	0.034549	0.0285978

Test: Ho: difference in coefficients not systematic

chi2(13) = (b-B)'[(V_b-V_B)^(-1)](b-B)= 125.38; Prob>chi2 = 0.0000

Annex V. Correlation matrix of coefficients of TFP model

e(V)	G	Ed	lnF	Ext	LnO	Rq	Rq*time	Ld	Irr	LnMd	LnFz	Trm	Mm	cons
G	1													
Ed	0.0406	1												
LnF	0.0338	-0.0328	1											
Ext	-0.0113	-0.0088	-0.0123	1										
O	-0.1076	0.0237	-0.1754	0.0356	1									
Rq	0.1065	0.0352	0.0629	0.0517	0.4186	1								
RQ*time	-0.1141	-0.0369	-0.0696	-0.1226	-0.4368	-0.9341	1							
Ld	-0.0249	-0.0455	-0.0278	0.0131	0.1814	-0.0416	0.0134	1						
Irr	-0.0004	-0.0088	-0.0163	-0.0338	-0.0168	-0.0032	0.0139	0.0105	1					
LnMd	0.0506	0.0049	0.0579	0.0302	0.0432	-0.0717	0.1221	-0.0205	-0.0409	1				
LnFz	-0.0168	0.0049	-0.0408	-0.2958	-0.2461	0.0393	-0.0194	-0.0475	-0.0148	-0.019	1			
Trm	0.0021	0.0178	0.008	0.0035	-0.0074	0.0768	-0.0756	0.0123	0.012	0.0301	-0.0243	1		
Mm	-0.0336	-0.0146	-0.0109	-0.024	-0.0688	0.0525	-0.0562	-0.0505	-0.0347	0.0468	-0.0121	0.2199	1	
cons	-0.767	-0.0661	-0.6035	-0.0151	0.1161	-0.1664	0.154	0.0279	-0.0112	-0.2959	-0.0488	-0.0368	-0.0056	1

G= gender; Ed; education; Extension; O; Oxen; RQ=road quality; LD; Lnd size; Irr; irrigation access Lnmd; mandays ;LnF; fertilizer ;Trm; traditional mode ;Mm; modern mode of transport.

Annex VI. Modified Wald test for groupwise heteroskedasticity in fixed effect regression model

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

chi2 (2168) = 1.1e+38

Prob>chi2 = 0.0000