# The Impact of Roads on Household Income in Rural Ethiopia

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**Abstract**

This study examines the role of roads in enhancing agricultural household's net farm income and explores plausible mechanisms related to their labour and output market participation decisions. The study uses the fourth wave of the Ethiopia Socioeconomic Survey (ESS), a nationwide household survey data consisting of a representative sample of over 3,000 agricultural households. The descriptive analyses show that agricultural households' access to quality roads is positively correlated with their commercialization decision, participation in off-farm activities, and net farm income. These results are further explored using the seemingly unrelated regression (SUR) and recursive bivariate regression (RBR) models to facilitate rigorous empirical estimation on how accessibility of quality roads affects household income and welfare in rural Ethiopia. Accordingly, the findings reveal that agricultural commercialization is significantly higher for agricultural households living within two kms to tar/asphalt road than for those who cannot access tar/asphalt road within two km. Similarly, agricultural households spend more hours in off-farm activities if they reside within two kms to tar/asphalt road. Ultimately, access to quality roads has a significant impact on agricultural households' net farm income indirectly through their agricultural commercialization decisions. In general, these results shed light on the importance of road infrastructure policy and programming to promote agricultural commercialization and livelihood diversification of agricultural households, and ultimately enhance household income in rural Ethiopia.

***Keywords:*** Agricultural commercialization, off-farm activities, net farm income, Ethiopia

# 1 Introduction

Agriculture is the dominant livelihood activity for the majority of the population in sub-Saharan Africa (SSA). Smallholder agricultural households[1] represent around 80 percent of the total farmlands and up to 70 percent of the national population in the region (Lowder et al., 2016). Poverty is disproportionately concentrated in the rural areas among agricultural households (WorldBank, 2007; FAO, 2015) that are estimated to represent three-quarters of the poor and hungry in SSA (Valdés et al., 2011). Ethiopia is the second most populous country in SSA with around 80% of its total population residing in rural areas (World Bank, 2021) relying on agriculture as a main source of livelihood. Commercial and livelihood transformations in many SSA countries, including in Ethiopia, would link agricultural households to input and output sides of agricultural markets (World Bank, 2012) and to additional income generating opportunities that collectively contribute towards improving household income and welfare of the rural population. Thus, agricultural commercialization and livelihood diversification are feasible pathways towards economic growth and development for many agrarian economies (Timmer, 1997; Anang et al.,2020).

Agricultural commercialization entails physical access to markets and actual market participation (sell of agricultural products and purchase of agricultural inputs). Agricultural households in SSA are confronted with serious challenges related to market access and participation due to lack of roads and transportation infrastructure (Jacoby, 2000; Årethun and Bhatta, 2012; Wudad et al., 2021) and supply chain and price information (Anderson, 2003; Hamill, 2017). Particularly, difficulty of accessing markets due to lack of road network has been a major challenge of market participation in the context of SSA. In Ethiopia, most agricultural households are poorly connected (Jemal and Genet, 2019; Gebresilasse, 2023)[2], which results in high transaction cost in terms of buying and selling agricultural products and other goods (Stifel and Minten, 2017). There isa huge potential to boost rural household income through increased participation in agricultural (input and output) markets and diversification of employment (Wakeyo et al., 2017; ILRI, 2020).

This study aims to examine whether and to what extent access to quality roads contributes towards promoting commercialization decisions, participation in off-farm activities, and ultimately net farm income and welfare of agricultural households. As such, the study contributes to the existing literature not only by examining determinants of market participation, off-farm employment, and household income,but also by simultaneously investigating associations between these three outcome variables of interest.In doing so, this study provides empirical insight into the extent to which quality roads affect net farmincome and welfare of agricultural households through commercialization and participation in off-farm income generating activities. The findings and recommendations of this study provide valuable input for the realization of the strategic pillars of Ethiopia's ten years perspective development plan (2021-2030),which maps the country's pathways to promote rural income growth to accelerate poverty reduction.

This study measures agricultural commercialization, off-farm activities and net farm income of agricultural households using data from ESS4, and explores the associations between them. The study is organized as follows. Section 2 provides a conceptual framework linking roads and market participation in the context of agricultural households. Section 3 describes the source of data and variables of interest. Section 4 discusses methods of data analysis. Section 5 presents descriptive statistics and econometric results of the study, and the discussion based on the results. Section 6 concludes and provides key recommendations.

[1]Smallholder agricultural households are family farms operating on less than two hectares of land.

[2]Based on own computation using the fourth wave of the Ethiopia Socioeconomic Survey (ESS4) shows that only 18 percent of the rural population live within two kms of tar/asphalt road. The 2019 data from World Economic Forum on quality of roads, 1(low) - 7(high), also show thatthe score for Ethiopia is lower than the average for SSA consisting of 34 countries.

## 2 Conceptual framework

The search for an explanation of agricultural households' decision-making in both perfect and incomplete market contexts led to the formulation of the agricultural household model (AHM). In the model, an agricultural household is both a producer who chooses the allocation of labour and other inputs to farm production, and a consumer who chooses the allocation of income from profit and labour sales to the consumption of goods and services (Singh et al., 1986; Taylor and Adelman, 2003). The household maximizes utility through the consumption of all available commodities (i.e., home-produced goods, market-purchased goods, and leisure), subject to households' budget constraints (Mendola, 2007). In AHM, the household division of labour is explained according to principles of comparative advantage; individual labour is allocated to tasks with lower opportunity cost (Evans, 1991). At the core of AHM is the issue of whether the household's production, consumption, and labour supply decisions are simultaneously determined or if they are separable. If agricultural households have access to input and output markets, prices are exogenous resulting in a separable decision-making process (Roe and Graham-Tomasi, 1985). As such, production decisions (input use and adoption of farm technologies) affect consumption exclusively via income levels, and production decisions are entirely independent of consumption.

However, in most developing countries, markets are incomplete and function poorly (de Janvry et al., 1991; Barrett, 2008) or may have high transaction costs (Ouma et al., 2010) for agricultural households and hence the decision process becomes non-separable (Singh et al., 1986; Taylor and Adelman, 2003; Mendola, 2007). Hence, their agricultural production decisions take into account their ability to ensure smooth consumption – for agricultural households it is usually about satisfying subsistence household consumption needs. As agricultural households face various forms of barriers to market access and participation (Barrett, 2008; Mmbando et al., 2015; Hagos et al., 2020), this may disincentivize them to produce agricultural outputs that are solely meant for sale or produce above subsistence needs, as their ability to sell marketable surplus is constrained.

In these circumstances, it is vital to consider the constraints generated by lack of road access to markets to examine agricultural households' production and consumption decisions that ultimately determine their income generating capacity. In the poverty reduction discourse, a growing attention has been devoted to correctly include considerations related to the role of access to markets (Anang et al., 2020) and the benefits of rural roads to that end. According to Gebremedhin and Jaleta (2010), interventions such as public infrastructure investments in road construction and maintenance to enhance market orientation could also help to promote market participation. Agricultural households' lack of access to markets and livelihood diversification opportunities may constrain their ability to generate income and meet their household consumption needs.

In this light, expanding rural road accessibility and connectivity can translate into improved access to markets and off- and non-farm employment opportunities for agricultural households. Enhancing market access can increase farm income generation (Aku et al., 2018). The income gains to agricultural households can be through livelihood diversification, increasing revenue from sale of farm products and/or reducing costs of production by improving access to agricultural inputs. This, in turn, enables agricultural households to make consumption expenditure on basic goods and services (Ogutu et al., 2020; Usman and Callo-Concha, 2021). In summary, enhanced rural connectivity can play a critical role in enhancing welfare of agricultural households and enabling them to break out of poverty traps.

# 3 Data and variables

This study used the Ethiopia Socioeconomic Survey (ESS), a nationally representative data set fielded in the year 2018/19 and consists of 6,770 households, out of which 46 percent are agricultural households. Though the ESS generates panel data for the years 2011/12, 2013/14 and 2015/16, the 2018/19 surveyround is not a follow-up of the previous waves. Therefore, ESS4[3] data set is used for this study as it presents the most recent data to simultaneously estimate determinants of market participation, off- farm employment, and household income, and investigate associations between equations of the three outcome variables.

## 3.1 Outcome variables of interest

**Net farm income**: Besides data on values of production and sale of agricultural and livestock products[4], ESS4 also contains data on costs of agricultural and livestock production. Net farm income for each farm household is computed by subtracting total farm production cost from total value of farm production. Moreover, the ESS4 also contains variant measures of household consumption expenditure, namely nominal and real household consumption expenditures. This study uses the real annual consumption per adult equivalent (i.e, annual consumption per adult equivalent spatially adjusted for price changes). The ESS4 survey data provide the real annual consumption per adult equivalent, which is obtained by dividing the nominal annual consumption per adult equivalent by regional spatial price index of 2018/19.

**Agricultural commercialization**: a commercialization index - constructed as a proportion of the value of the sales of a household relative to its total value of farm produce (consisting of crop and livestock production). Farm commercialization index (FCI) is the ratio of total value of crop and livestock sale to total value of crop and livestock production. Similarly, crop commercialization index (CCI) and livestock commercialization index (LCI) can also be separately measured by dividing total value of sale by total value of production of crop and livestock products, respectively.

**Off-farm employment**: Data on participation in off-farm activities along with income households earn from these activities are also available in the data.

## 3.2 Key explanatory variables of interest

The main explanatory variable of interest is agricultural households' access to quality roads, which is measured using whether or not sample agricultural households reside within two kms of tar/asphalt road. As explained in section 2, production decisions in terms of farm or off-farm enterprise choice can be influenced by rural/market accessibility indicators. In this respect, households in areas with better access to quality roads may have better market participation and off-farm employment opportunities than those in areas with lower rural connectivity.

## 3.3 Control variables

This study also controls for the effects of other demographic, socio-economic and community characteristics of agricultural households that can influence farm income, market participation, and off-farm employment.

[3]In the ESS4 data, enumeration area (community) identifier provides the smallest sub-place in the data to aggregate sample households to a very small locality. The total number of enumeration areas in the data set is 535, and the average number of sample households per enumeration area is around 13, ranging between 4 and 16.

[4]Unit prices for each agricultural and livestock products were computed using 'sales value' and 'quantity sold' variables in the data set.

# 4 Empirical estimation strategy

Using a naïve regression model in equation 1, the effect of agricultural households' access to roads on farm income can be estimated by regressing the variable representing farm income ($Y_i$) on road connectivityof the household ($R_i$), a vector of household characteristics ($x_i$), and an error term ($\omega_{1i}$). $\alpha_1$ and $\beta_1$ are unknown parameters to be estimated. The same can be done to separately estimate how access to roadsaffect market participation and off- and non-farm employment decisions of agricultural households, as shownin equations 2 and 3 respectively.

$$Farm\ Income_i\ (Y_i) = \alpha_1 R_i + x_i\beta_1 + \omega_{1i},\ \omega_1 \sim \mathrm{N}(0, \sigma^2) \quad (1)$$

$$Market\ Participation_i = \alpha_2 R_i + x_i\beta_2^{'} + \omega_{2i},\ \omega_2 \sim \mathrm{N}(0, \sigma^2) \quad (2)$$

$$Off-farm\ Employment_i = \alpha_3 R_i + x_i\beta_3^{'} + \omega_{3i},\ \omega_3 \sim \mathrm{N}(0, \sigma^2) \quad (3)$$

where the subscripts indicate variation over agricultural households (i = 1, 2, ..., N). The outcome variables ofinterest are household income, market participation, and off- and non-farm employment.

For this study, however, the assumption that the outcome variables are independent is unrealistic due to non-separable production, consumption and labour supply decisions (see section **2**). To account for this, this study uses a maximum likelihood estimator for the three outcomes with a binary regressor ($R_i$) under the seemingly unrelated regressions (SUR) model.[5] The maximum likelihood estimators have the properties of being consistent and asymptotically efficient (Greene, 2012). The SUR model jointly determines equations 1, 2 and 3 as a system of three equations that allows the error terms to be correlated. This facilitates estimation of the coefficient on $R_i$ as the unbiased measure for the average treatment effect (ATE) – the average effect of changing the whole rural population from no access to having access to quality roads. $(\omega_{1i}, \omega_{2i}, \omega_{3i})^{'}$ is a vector of error terms that follows a multivariate standard normal distribution with correlation coefficients $\rho$ described as;

$$\omega_{1i}\ \omega_{2i}\ \omega_{3i}\ \sim N\left((0\ 0\ 0)', \begin{bmatrix} 1 & \rho_{12} & \rho_{13} \\ & 1 & \rho_{23} \\ & & 1 \end{bmatrix}\right)$$

# 5 Results

To facilitate detailed discussion, the results from the descriptive analyses and the econometric analyses using SUR model are presented separately in the following sub-sections.

## 5.1 Descriptive statistics

The mean, standard deviation and range of the outcome variables, the explanatory variable of interest and the control variables are presented in Table 1. On average, agricultural households earn a net farm income of around 30,000 ETB and incur per capita real consumption expenditure of 13,520 ETB during the 2018/19 production year. During the same period, in terms of commercialization, agricultural households sell around 20% of their agricultural production (constituting 22.4% of their crop production and 12.2% of their livestock production). Agricultural households also spent on average around three hours on off-farm activities (2.2 hours on own or household business and 0.7 hours on casual/temporal labour activities). Using a rural connectivity indicator, around 18% of agricultural households reside within two kms to asphalt/tar road. The descriptive statistics for the control variables are also presented in the table.

[5]If the continuous commercialization index and/or off-farm engagement variables are considered as endogenous regressors in the equation determining net farm income (i.e., in equation 1), the model becomes recursive bivariate regression (RBR). For each endogenous regressor, the RBR model requires at least one exclusion restriction/instrumental variable, which will not affect net farm income directly (but only through the endogenous regressor). User written Stata command developed by Roodman (2011) can be used to estimate the parameters under the SUR and RBR models.

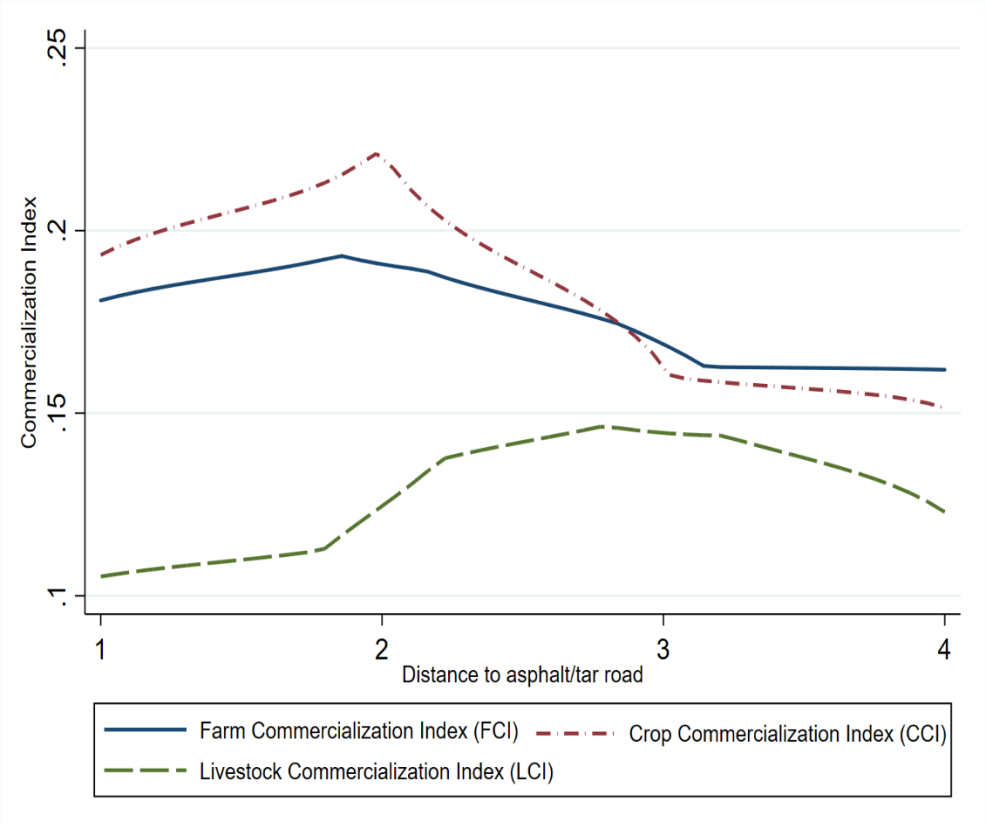
**Table 1:** Descriptive statistics for the outcome and explanatory variables

| Variable | Obs | Mean | Std.Dev. | Min | Max |
|---|---|---|---|---|---|
| Net farm income (in ETB) | 2,047 | 29,943.02 | 113,423.3 | -13,400.09 | 6,865,432 |
| Per capita real consumption exp. (in ETB) | 2,059 | 13,520 | 12,352 | 272.6 | 169,992 |
| Crop Commercialization Index (CCI) | 2,022 | 0.224 | 0.284 | 0 | 1 |
| Livestock Commercialization Index (LCI) | 1,411 | 0.122 | 0.252 | 0 | 1 |
| Farm Commercialization Index (FCI) | 2,043 | 0.198 | 0.256 | 0 | 1 |
| Hrs. spent per week on own account/HH business | 2,059 | 2.181 | 9.174 | 0 | 120 |
| Hrs. spent per week on casual/temporary labour | 2,059 | 0.667 | 4.893 | 0 | 64 |
| Total hrs. spent per week on off-farm activities | 2,059 | 2.847 | 10.911 | 0 | 126 |
| Asphalt/tar road within two km (binary; 1 within 2 km, 0 more than 2 km) | 2,013 | 0.184 | 0.387 | 0 | 1 |
| Number of crops grown | 2,050 | 4.836 | 2.863 | 1 | 17 |
| Relative price (in ETB) of staples to cash crops | 2,047 | 0.550 | 1.132 | 3.76e-05 | 10.48 |
| Post-harvest crop loss (percent) | 2,020 | 0.446 | 3.128 | 0 | 100 |
| Sex of the hh head (binary; 1 male, 0 female) | 2,059 | 0.805 | 0.397 | 0 | 1 |
| Age of the HH head | 2,059 | 45.67 | 15.34 | 15 | 97 |
| Ability of the HH head to read and write (binary; 1 if the head can read and write, 0 otherwise) | 2,058 | 0.410 | 0.492 | 0 | 1 |
| Family size | 2,059 | 5.213 | 2.189 | 1 | 19 |
| Total landholding (in ha) | 2,059 | 1.087 | 1.180 | 0.00318 | 25.46 |
| Livestock holding (in Tropical Livestock Unit (TLU)) | 2,059 | 8.011 | 24.54 | 0 | 964.1 |
| Private transfer (binary; 1 HH receive private transfers, 0 otherwise) | 2,027 | 0.110 | 0.313 | 0 | 1 |
| Social assistance (binary; 1 HH receive social assistance, 0 otherwise) | 2,022 | 0.0977 | 0.297 | 0 | 1 |
| Credit/ take out loan during the production year (binary; 1 yes, 0 otherwise) | 2,059 | 0.147 | 0.355 | 0 | 1 |
| Farm type (1 if mixed farm; 0 if crop only) | 2,050 | 0.865 | 0.342 | 0 | 1 |
| Plot under extension program (binary; 1 yes, 0 otherwise) | 2,059 | 0.424 | 0.494 | 0 | 1 |
| Own mobile or landline phone (binary; 1 yes, 0 otherwise) | 2,044 | 0.407 | 0.491 | 0 | 1 |

Note: The number of observations for each variable is based on non-missing values. The descriptive statistics are computed using sample weights provided in the data. Livestock holding is measured TLU based on Jahnke (1982) conversion factors as Camel 1.0, horse 0.8, cattle and mule 0.7 each, donkey 0.5, pig 0.2, sheep and goat 0.1 each and chicken 0.01.

Figure 1 shows that households' farm and crop commercialization indexes (FCI and CCI) follow a similar trend, and overall they decline with an increase in distance of the households to asphalt/tar roads. This association however is non-linear as FCI and CCI first increase with an increase in distance to quality rural roads, then followed by inverse associations - a decline as distance to asphalt/tar road increases. As such, the shape of FCI is predominantly determined by the CCI. Agricultural households living within two to five kms of tar/asphalt road have better market participation in terms of selling more than 20% of their crop production (which makes it around 20% of their total farm production). For any agricultural households residing beyond 5 kms to tar/asphalt roads, CCI and consequently FCI decline with an increase in their distance to the roads. However, LCI tends to increase so long as households' distance to tar/asphalt roads is below 10 kms. In general, agricultural households living 10 to 15 kms away from tar/asphalt roads are selling around 7 percentage points less crop products than those living within two to five kms. Similarly, FCI is also less for those living 10 to 15 kms away from tar/asphalt roads than those living within two to five kms.

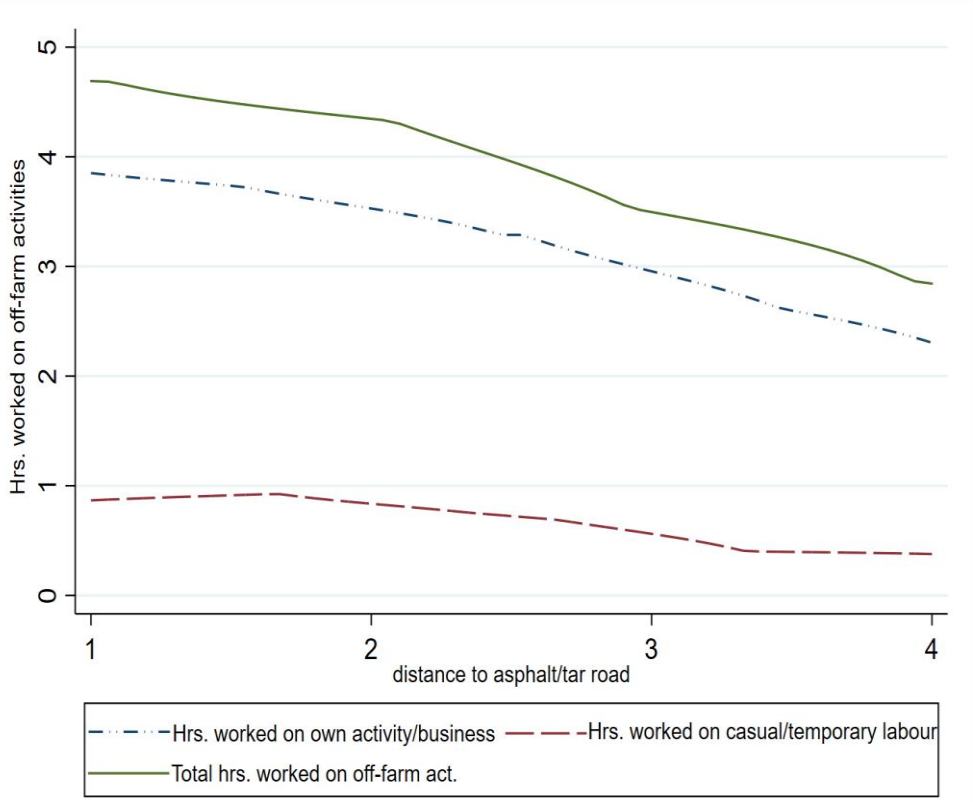
**Figure 1:** Agricultural commercialization and distance to tar/asphalt road




Source: Own elaboration based on ESS4 data.

Figure 2 shows inverse associations between distance to asphalt/tar road and households' time spent per week on off-farm activities consisting of own/household business and casual/temporary labour. Agricultural households living within two kms to tar/asphalt roads spend two more hours per week on off-farm activities than those living 10 to 15 kms away from tar/asphalt roads. This can be explained by a finding by Huang et al. (2022) that accessibility of rural transportation infrastructure is positively correlated with non-farm employment of rural households.

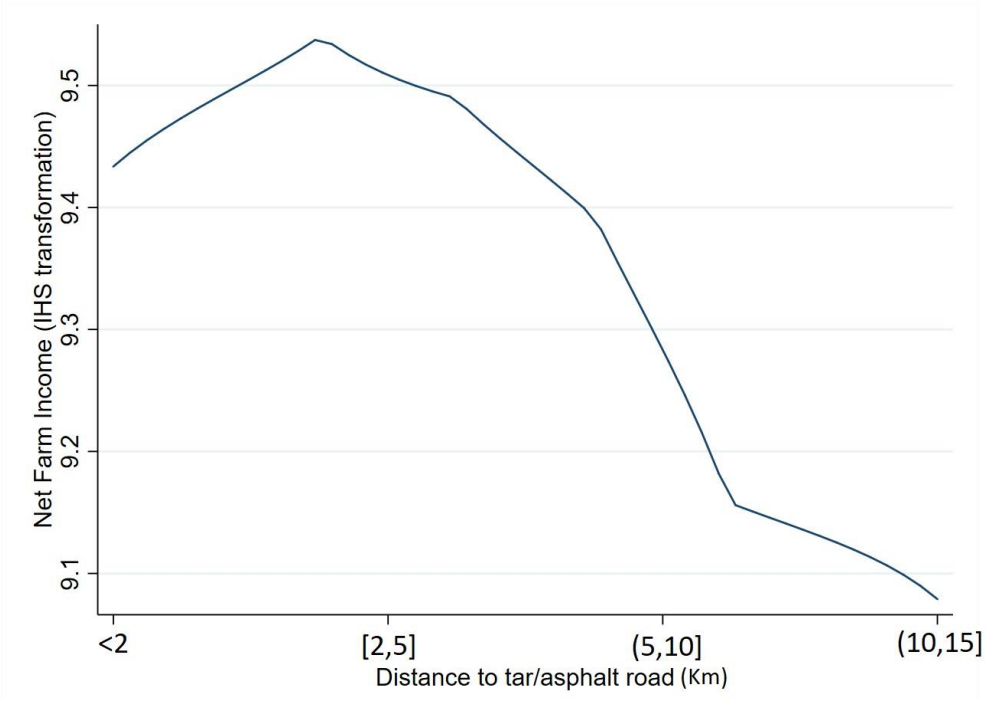
**Figure 2:** Off-farm activity and distance to tar/asphalt road




Source: Own elaboration based on ESS4 data

The association between distance to asphalt/tar road and net farm income shows a similar trend as CCI and FCI. Net farm income drastically falls with distance to tar/asphalt road for agricultural households living beyond 5 kms (see Figure 3). This is particularly apparent as agricultural households residing further from two to five kms from tar/asphalt roads sell a smaller proportion of their crop and farm production, which may lead to a reduction in their net farm income.

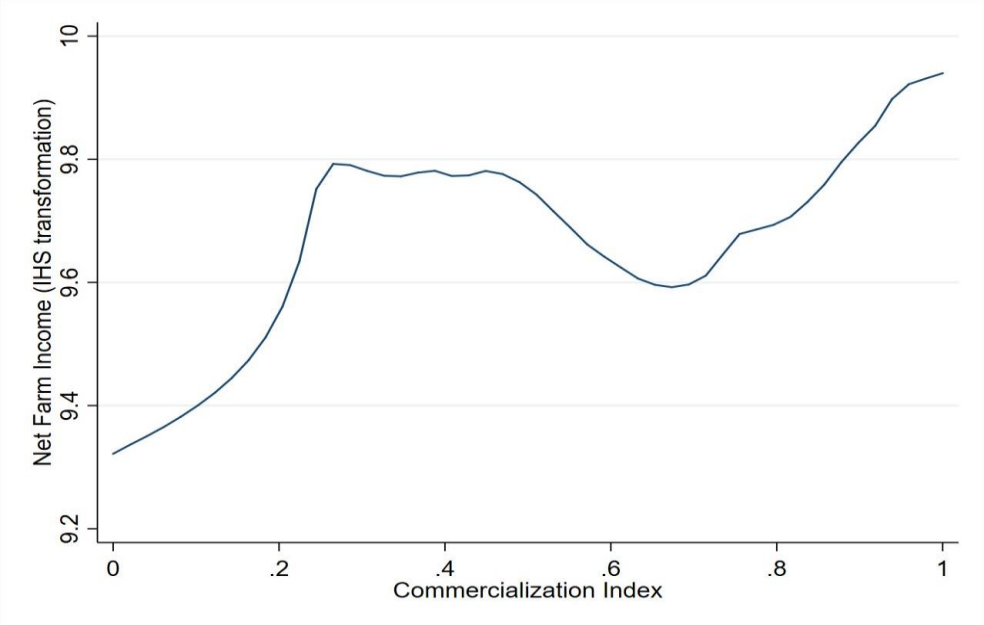
**Figure 3:** Net farm income and distance to tar/asphalt road




Source: Own elaboration based on ESS4 data

Figures 4-6 show the extent to which agricultural commercialization and off-farm employment are correlated with household income and welfare. The y-axis in Figures 4 and 5 is inverse hyperbolic sine (IHS) transformed net farm income. IHS transformation is more appropriate for net farm income than logarithmic transformation as net farm income could take zero or even negative values. The y-axis in Figure 6 is logarithmic transformed real per capita consumption expenditure as this variable could not be zero or negative. Accordingly, Figure 4 shows that household commercialization index has a positive correlation with net farm income.

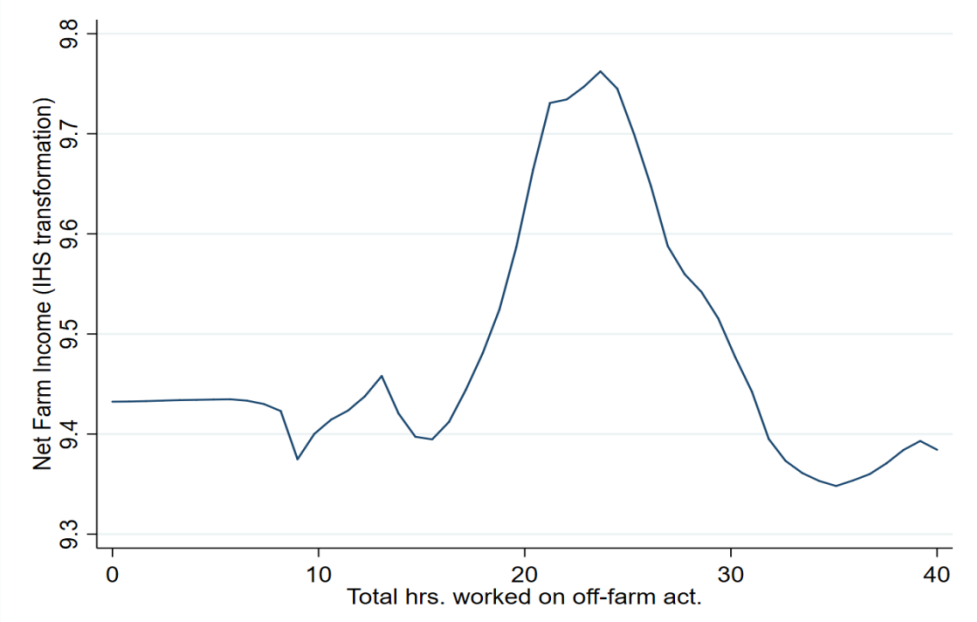
**Figure 4:** Net farm income and agricultural commercialization




Source: Own elaboration based on ESS4 data

As shown in Figure 5, there is a parabolic association between off-farm employment and net farm income. As such, net farm income tends to increase with an increase in off-farm employment so long as the weekly time spent on those activities does not exceed 25 hours per week, beyond which off-farm employment is negatively associated with net farm income. This could be explained by a plausible diversion of household labour from farm activities to off-farm employment, which may affect farm production and the income that can be generated from it.

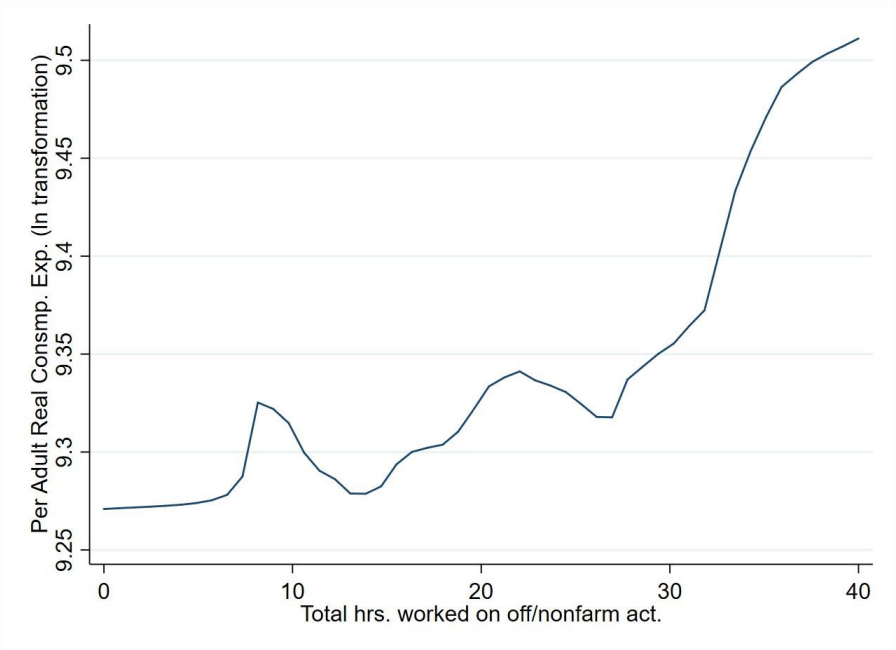
**Figure 5:** Net farm income and off-farm activity




Source: Own elaboration based on ESS4 data

However, this is not the case for the association between off-farm employment and household welfare. Per capita real consumption expenditure of agricultural households tends to increase with an increase in their time spent on off-farm activities. This suggests the income that agricultural households generate from non-farm employment is intended to be spent on household consumption.

**Figure 6:** Off-farm activity and household welfare




Source: Own elaboration based on ESS4 data

## 5.2 Results from econometric analyses

As shown in Table 2, there are a number of variables that significantly correlate with agricultural commercialization (column 1), off-farm activities (column 2) and net farm income (column 3). As shown in Table 3, the SUR model consistently identifies statistically significant determinants of agricultural households' commercialization decision and participation in off-farm activities regardless of a change in the third outcome variable from net farm income to per capita real consumption expenditure. As expected, accessibility of quality roads as measured using living within two km of asphalt/tar road is significantly correlated with agricultural households' agricultural commercialization index and time spent on off-farm activities (columns 1 and 2 in Tables 2 and 3). For agricultural households, living within two km of asphalt/tar road is associated with around 4.5 percentage points increase in farm commercialization and spending around three additional hours on off-farm employment than living beyond two kms to asphalt/tar road. Similar to this study, Årethun and Bhatta (2012) and Wudad et al. (2021) revealed the desirable role of road infrastructure on market participation of agricultural households in Ethiopia. Huang et al. (2022) also report that agricultural households with a greater access to transportation infrastructure are more willing to take off-farm employment.

While living within two km of asphalt/tar road is not directly correlated with net farm income of agricultural households, it has significant correlation with their per capita real consumption expenditure (column 3 in Tables 2 and 3). Being a male household head is correlated with net farm income, and this could be due to cultural influences of patriarchal societies that favour males over females to have better access to agricultural resources and inputs as reported in Ajadi et al. (2015) and Nnaji et al. (2021). Household heads' ability to read and write is positively correlated with commercialization decisions, participation in off-farm activities, and per capita real consumption expenditure of agricultural households. These characteristics of the household head may determine households' ability to access and utilize production- and market-related information. This finding

is in line with Hoq et al. (2021) who found that education levels and access to market information had a positive impact on market participation. Number of economically active household members is positively correlated with net farm income, but it is negatively correlated with per capita real consumption expenditure. Access to credit is positively correlated with commercialization and off-farm employment. Landholding and number of crops grown by the household (a proxy for crop diversification) have a positive correlation with agricultural commercialization and net farm income.

These variables can play a role in increasing total farm production and thus marketable surplus, and reducing production risks. It has been previously documented that market participation is positively correlated with farm size (Abdullah et al., 2019), crop diversification (Mango et al., 2018), and access to credit (Hoq et al., 2021). A study by Noack and Larsen (2019) similarly shows that farmers benefit from larger farms by earning higher and more stable incomes. The positive benefits of crop diversification in enhancing production and productivity are shown in Beillouin et al. (2021) and Stefan et al. (2021), respectively. Though agricultural households' access to communication via mobile/fixed line phone is positively correlated with both commercialization and off-farm employment, it is statistically significant only for the latter. Consequently, access to communication through mobile/fixed line phone has a positive and statistically significant correlation with per capita real consumption expenditure of agricultural households, but not with their net farm income.

**Table 2:** Commercialization, off-farm activities and net farm income under SUR model

| Variables | (1)<br>FCI | (2)<br>Off-farm Act. | (3)<br>Net Farm Income |
|---|---|---|---|
| within 2 km to tar/asphalt road | 0.0447*** | 2.9095*** | 0.1887 |
| | (0.0143) | (0.8687) | (0.1641) |
| sex of the hh head | 0.0136 | -0.1137 | 0.6892*** |
| | (0.0143) | (0.6689) | (0.1905) |
| age of the hh head | -0.0000 | -0.0200 | -0.0037 |
| | (0.0004) | (0.0165) | (0.0042) |
| read and write | 0.0280** | 1.4718** | -0.1863 |
| | (0.0120) | (0.6128) | (0.1523) |
| no. of working age hh members | 0.0006 | 0.2858 | 0.1388** |
| | (0.0048) | (0.2022) | (0.0550) |
| private transfer | 0.0014 | -0.6727 | 0.1505 |
| | (0.0183) | (0.8053) | (0.2103) |
| social assitance | -0.0241 | -0.9633 | 0.3300** |
| | (0.0162) | (0.7802) | (0.1482) |
| credit access | 0.0378** | 1.5930* | -0.0236 |
| | (0.0166) | (0.8939) | (0.1740) |
| landholding | 0.0142*** | 0.0565 | 0.3587*** |
| | (0.0050) | (0.3518) | (0.0830) |
| TLU | -0.0003** | -0.0072** | 0.0001 |
| | (0.0001) | (0.0029) | (0.0016) |
| farm type | -0.0593*** | -2.5016** | 0.7550*** |
| | (0.0177) | (1.0098) | (0.1982) |
| number of crops grown | 0.0096*** | -0.0714 | 0.1652*** |
| | (0.0023) | (0.0971) | (0.0381) |
| post-harvest crop loss | -0.0022*** | -0.0819*** | -0.0836* |
| | (0.0007) | (0.0241) | (0.0507) |
| agri. extension service access | 0.0087 | -0.0056 | 0.2013 |
| | (0.0116) | (0.6160) | (0.1304) |
| mobile/line phone | 0.0048 | 2.7662*** | -0.0105 |
| | (0.0112) | (0.6169) | (0.1436) |
| staples to cash crops relat. price | -0.0223*** | 0.4192 | -0.0054 |
| | (0.0046) | (0.4422) | (0.0543) |

| | | | |
|---|---|---|---|
| region dummies | yes | yes | yes |
| constant | 0.1147*** | 5.7165*** | 6.6183*** |
| | (0.0280) | (1.5791) | (0.4462) |
| rho_12 | | 0.0207 | |
| | | (0.0226) | |
| rho_13 | | 0.0441* | |
| | | (0.0243) | |
| rho_23 | | -0.0086 | |
| | | (0.0266) | |
| Observations | | 1900 | |

Robust standard errors in parentheses
*p<0.1, ** p<0.05, *** p<0.01

On the contrary, while livestock holding and farm type are negatively correlated with household CI and off-farm employment, post-harvest crop loss is negatively correlated with all of the dependent variables showing that post-harvest loss is a significant threat to household income and welfare. Though livestock holding and mixed crop-livestock farming have negative correlations with households' commercialization and off-farm employment, their correlations with net farm income and per capita real consumption expenditure are either non-significant or positive. Staples to cash crops relative price has a negative correlation with household commercialization decisions. The plausible explanation is that agricultural households may intend to produce staple crops primarily for home consumption aiming to avoid paying higher prices to buy them from the marketplace.

Besides identifying statistically significant determinants of agricultural commercialization, off-farm employment, and household income and welfare, this study also relies on the SUR model to simultaneously take into account the possible associations between the three dependent variables of interest. The ρ12, ρ13 and ρ23 in Table 2 and Table 3 present the level of associations between the outcome equations. Agricultural commercialization is positively associated with both net farm income and per capita real consumption expenditure of households. While the association between agricultural households' off-farm employment and per capita real consumption expenditure is positive and statistically significant, the association between their off-farm employment and net farm income is negative, which is as expected, but not statistically significant. This finding suggests off-farm income may not be reinvested for farm activities to enhance net farm income, rather rural households may use the income they generate from their off-farm employment to purchase basic goods and services from the market to meet household consumption needs. Furthermore, as shown in Figure 5, off-farm employment may compete for available household labour that can be utilized for farm activities, which may have adverse consequences on farm income. This provides evidence that access to quality roads affects rural households' net farm income only through their commercialization decision.

**Table 3:** Commercialization, off-farm activities and per capita real consumption exp. under SUR model

| Variables | (1) FCI | (2) Off-farm Act. | (3) Real Consmp. Exp |
|---|---|---|---|
| within 2 km to tar/asphalt road | 0.0447*** | 2.9095*** | 0.1591*** |
| | (0.0143) | (0.8687) | (0.0410) |
| sex of the hh head | 0.0136 | -0.1137 | -0.0540 |
| | (0.0143) | (0.6689) | (0.0428) |
| age of the hh head | -0.0000 | -0.0200 | 0.0060*** |
| | (0.0004) | (0.0165) | (0.0011) |
| read and write | 0.0280** | 1.4718** | 0.1013*** |
| | (0.0120) | (0.6128) | (0.0331) |
| no. of working age hh members | 0.0006 | 0.2858 | -0.1579*** |
| | (0.0048) | (0.2022) | (0.0140) |
| private transfer | 0.0014 | -0.6727 | 0.0398 |
| | (0.0183) | (0.8053) | (0.0543) |

| | | | |
|---|---|---|---|
| social assitance | -0.0241 | -0.9633 | -0.0751* |
| | (0.0162) | (0.7802) | (0.0452) |
| credit access | 0.0378** | 1.5930* | 0.0423 |
| | (0.0166) | (0.8939) | (0.0414) |
| landholding | 0.0142*** | 0.0565 | 0.0325** |
| | (0.0050) | (0.3518) | (0.0131) |
| TLU | -0.0003** | -0.0072** | 0.0003 |
| | (0.0001) | (0.0029) | (0.0004) |
| farm type | -0.0593*** | -2.5016** | 0.0181 |
| | (0.0177) | (1.0098) | (0.0427) |
| number of crops grown | 0.0096*** | -0.0714 | -0.0072 |
| | (0.0023) | (0.0971) | (0.0061) |
| post harvest crop loss | -0.0022*** | -0.0819*** | -0.0060** |
| | (0.0007) | (0.0241) | (0.0029) |
| agri. extension service access | 0.0087 | -0.0056 | 0.0600* |
| | (0.0116) | (0.6160) | (0.0323) |
| mobile/line phone | 0.0048 | 2.7662*** | 0.2045*** |
| | (0.0112) | (0.6169) | (0.0323) |
| staples to cash crops relat. price | -0.0223*** | 0.4192 | -0.0004 |
| | (0.0046) | (0.4422) | (0.0145) |
| region dummies | yes | yes | yes |
| constant | 0.1147*** | 5.7165*** | 9.1525*** |
| | (0.0280) | (1.5791) | (0.0797) |
| rho 12 | | 0.0207 | |
| | | (0.0226) | |
| rho 13 | | 0.0457* | |
| | | (0.0235) | |
| rho 23 | | 0.0587*** | |
| | | (0.0225) | |
| Observations | | 1900 | |

Robust standard errors in parentheses.
*p< 0.1, ** p<0.05, *** p<0.01

Therefore, this study proceeded with estimating the impact of agricultural commercialization on net farm income of agricultural households using their distance to asphalt/tar road as an instrument.[6] Table 4 presents the estimates on the impact of commercialization on net farm income using RBR model (see footnote 5 in section 4 for explanations about the model). The results show that agricultural commercialization significantly increases net farm income of agricultural households in Ethiopia. The average treatment effect estimate shows that net farm income of agricultural households in Ethiopia increases by 0.243 percent for a one percent increase in household commercialization index.[7] As such, on average, net farm income in rural Ethiopia can increase by around 25% if households double their market participation (i.e., by selling around 40% of their farm production). The findings of this study are in line with recent studies that show market participation had a statistically significant positive impact on household food security and income in Nigeria Manda et al. (2020) and per capita consumption expenditure in Pakistan (Abdullah et al., 2019).

[6]One may pose a question on the exogeneity of this instrument by arguing that agricultural households may self-select into areas with access to quality roads. However, the land tenure system in Ethiopia is a peculiar case that certainly creates a disincentive to people for moving away from their community (Melesse and Cecchi, 2017), as they will lose their 'use right' for their land in the community if they are no longer living there. It is unlikely that agricultural households relocate for accessing roads or other reasons as they cannot find land to use in the communitythey want to move as agricultural land is a very scarce resource in Ethiopia and there is no market for land because people only have use right - they do not have the right to freely sell or transfer the land.

[7]The parameter estimate for agricultural commercialization in Table 4 cannot provide a straightforward interpretation as the dependent variable (i.e., net farm income) is inverse hyperbolic sine (IHS) transformed. Bellemare and Wichman (2020) provide the formulas and Stata codes to estimate elasticities based on IHS (or arcsinh) transformed variables.

**Table 4:** Impact of agricultural commercialization on net farm income

| | Recursive Bivariate Regression | |
|---|---|---|
| | Farm CI (FCI) | Net Farm Income |
| within 2km to tar/asphalt road | 0.0454*** | |
| | (0.0143) | |
| farm commercialization index (FCI) | | 1.2246** |
| | | (0.5497) |
| sex of the hh head | 0.0138 | 0.6323*** |
| | (0.0143) | (0.1886) |
| age of the HH head | -0.0000 | -0.0036 |
| | (0.0004) | (0.0042) |
| read and write | 0.0279** | -0.2035 |
| | (0.0120) | (0.1482) |
| no. of working age hh members | 0.0006 | 0.1360** |
| | (0.0048) | (0.0547) |
| private transfer | 0.0014 | 0.1429 |
| | (0.0183) | (0.2069) |
| social assitance | -0.0241 | 0.3554** |
| | (0.0162) | (0.1468) |
| credit access | 0.0378** | -0.0793 |
| | (0.0166) | (0.1726) |
| landholding | 0.0142*** | 0.3452*** |
| | (0.0050) | (0.0848) |
| TLU | -0.0003** | 0.0005 |
| | (0.0001) | (0.0017) |
| farm type | -0.0594*** | 0.8416*** |
| | (0.0177) | (0.1956) |
| number of crops grown | 0.0097*** | 0.1479*** |
| | (0.0023) | (0.0376) |
| post harvest crop loss | -0.0022*** | -0.0817 |
| | (0.0007) | (0.0504) |
| agri. extension service access | 0.0089 | 0.1554 |
| | (0.0116) | (0.1243) |
| mobile/line phone | 0.0046 | 0.0235 |
| | (0.0112) | (0.1398) |
| staples to cash crops relative price | -0.0223*** | 0.0081 |
| | (0.0046) | (0.053 |
| region dummies | yes | 8) |
| | | yes |
| constant | 0.1145*** | 6.5302*** |
| | (0.0279) | (0.4453) |
| rho | | -0.0579 |
| | | (0.0446) |
| Observations | | 1945 |

Standard errors in parentheses

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

# 6 Conclusion and recommendations

This paper uses net farm income, agricultural commercialization and off-farm employment of agricultural households obtained from ESS4 data, and relates them to access to quality roads. The results from the descriptive analyses highlight that agricultural households' agricultural commercialization and participation in off-farm income generating activities are negatively influenced by distance to asphalt/tar road. Similar trend is observed for net farm income of agricultural households in association with access to quality roads. As expected, net farm income

also tends to increase with an increase in agricultural households' agricultural commercialization decision. It is also not surprising to see a non-linear association between net farm income and off-farm employment of agricultural households. Net farm income starts by increasing with an increase in time spent per week on off-farm activities, but followed by a decline as households spend more and more time on off-farm employment. Though spending the majority of agricultural households' time on off-farm activities may compete with the time available for agricultural activities, this livelihood diversification strategy is not at the cost of household welfare as it is positively correlated with per capita real consumption expenditure.

The econometric analyses using SUR probed the descriptive results to rigorously examine determinants of agricultural commercialization, off-farm employment and net farm income of rural house- holds, and explore associations between the three outcome variables of interest. Accordingly, agricultural commercialization and participation in off-farm income generating activities of rural households are positively determined by accessibility of tar/asphalt road. Concerning the correlations between the outcome variables, while agricultural commercialization is positively associated with both net farm income and per capita real consumption expenditure of households, off-farm employment is positively associated with the latter but not with the former. The results from the RBR model show that access to quality roads has a significant impact on net farm income of agricultural households through their agricultural commercialization decisions.

The study contributes to the evidence base on the impact of access to quality roads on rural household income and broadens our understanding of its desirable effects through promoting agricultural commercialization and off-farm employment. Based on the findings of this study, a direct action would be investments in infrastructure to expand rural road accessibility and connectivity, which would translate into improved participation in input, output and labour markets and ultimately rural household income in Ethiopia. This is in line with previous studies that highlighted, taking into account inadequacies in the available policy instruments for reaching the rural poor, road-building would seem desirable on market participation (Årethun and Bhatta, 2012; Hoq et al., 2021; Wudad et al., 2021) and distributional grounds (Jacoby, 2000). Future experimental evaluation studies would further shed light into the impact of rural road construction and maintenance interventions on the fight against rural poverty through promoting input, output and labour market access and participation of the majority of the population in Ethiopia.

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